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ABSTRACT

This document is designed to provide basic information about the climates of the United States and the causes of these climates. Events of interest in the climatological history of the United States are described and illustrated by many maps, charts and diagrams. The booklet has three major parts. Part I discusses climate and climate control in general and the geographical factors affecting it. Part II contains general summaries with respect to temperature, precipitation, storms, and miscellaneous phenomena such as floods, droughts, fog, and sunshine. Part III includes 63 illustrative maps. (GA)

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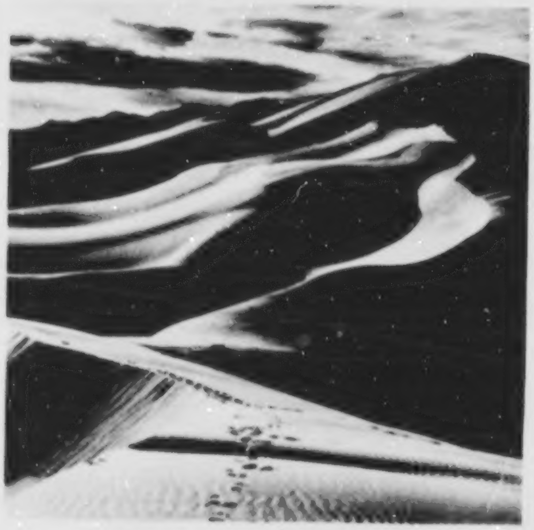
CLIMATES OF THE UNITED STATES



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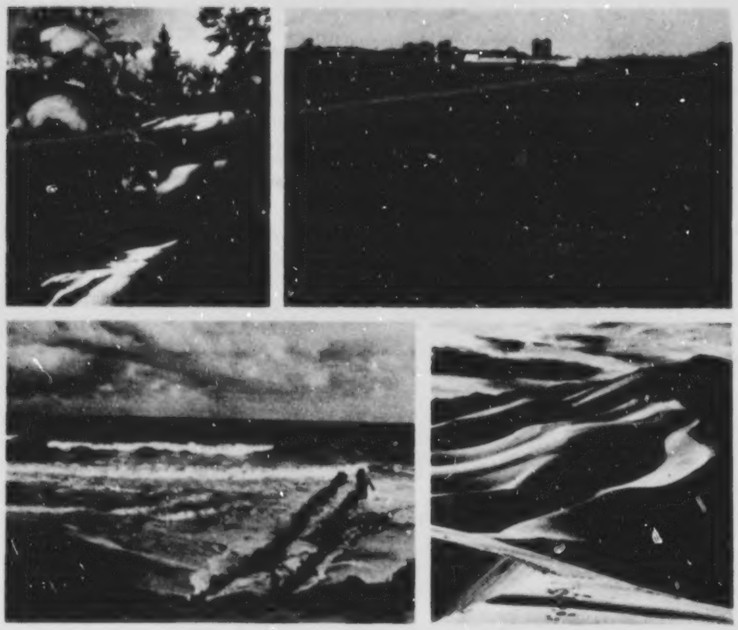
CLIMATES OF THE UNITED STATES

JOHN L. BALDWIN



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The author, now retired, was Chief of the Domestic Climatology Branch of the Environmental Data Service of the National Oceanic and Atmospheric Administration, an agency of the U.S. Department of Commerce. He also was Editor of the *Weekly Weather & Crop Bulletin* for 25 years prior to his retirement in 1970.

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Preface

This book with its numerous maps of the various elements of the climates of the United States was written in response to the constant demand for information experienced by the author during his 42 years as a Government climatologist.

The climates of the United States, the causes of these climates, and events of interest in the climatological history of the United States are described in the text and illustrated by many maps and diagrams. Most of the maps were adapted from the *Climatic Atlas of the United States* and modified to make them easier to use.

The author wishes to express his appreciation to many people:

The more than 100,000 volunteer observers who during the years since colonial times donated their time and effort to recording meticulously millions of daily observations of weather phenomena. This corps of volunteer observers—currently 13,000 are daily recording temperature, precipitation, and other weather phenomena—is largely responsible for the data that have made possible the long-term climatological records of the Nation;

The thousands of dedicated National Weather Service meteorologists and weather observers who for more than 100 years have provided detailed daily records of a large variety of weather data; and

The State and regional climatologists and hydrologists of the National Weather Service, the personnel of the Environmental Data Service (in the field, at the headquarters, and at the National Climatic Center at Asheville, N.C.), and many others for their direct and indirect contributions to the building of climatological records of the United States.

Finally, I would like to thank Paul E. Lehr of the Environmental Data Service Environmental Science Information Center for his invaluable advice and assistance in organizing the contents and planning the format of this book. His efforts have made it a better publication.

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Part I: Climate and Climate Controls

Chapters 1 and 2 define climate and climatology and show how various geographic and atmospheric phenomena affect climate. The climates of seven regions of the conterminous United States and the climates of Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands are described as general background for the detailed discussions of part II.

Chapter 1

Climate and Its Causes

INTRODUCTION

Some of the most pleasant, most severe, and most invigorating climates in the world can be found in the United States. These and a wide variety of climates occur over a land area of about three and one-half million square miles. Mountains, valleys, plains, lakes, coastal lowlands, and islands make up the territory of the Nation. Each feature has its own climatic characteristics, and each is a variation within one of the four broad climatic zones of the United States—Arctic, Temperate, Subtropical, and Tropical.

In this book, the author will describe the various climates and climatic features of the United States, tell something about the climatic history of the Nation, and provide some background on why various climates occur.

CLIMATE

The climate of a place is the long-term normal weather for that place—for a given day of the year or over a specified interval of time such as a month, a season, or a year. It is the weather we expect for spring in our home town, summer in New York City, or vacation time at our favorite fishing grounds. These expectations are predicated on the results of the statistical characterization of weather data collected over a relatively long period, usually several decades. In contrast, weather is the current or relatively recent state of the atmosphere. Both can be described in terms of temperature, pressure, humidity, and sunshine (and in the conditions that derive from them, such as winds, clouds, and precipitation). For example, temperature in weather is the current temperature at a place, while temperature in climate is the average temperature for the location, the average having been determined from records of temperatures that occurred over previous years.

CLIMATOLOGY

Climatology is the scientific study of climate. A climatologist may study the causes of climate or may be interested in the uses of climatic data for agriculture, industry, aviation, or any one of many fields of human endeavor. But the first task of climatology is to describe climate by tabulating, statistically analyzing, and graphing or charting records on weather elements and weather phenomena. The basic elements of weather (temperature, pressure, humidity, precipitation, winds, clouds, sunshine, and visibility) and storms (hurricanes, tornadoes, and thunderstorms) are observed and recorded. After the observations are used operationally, records of the observations are stored in archives. The climatologist uses these records to determine means (averages), extremes, totals, probabilities, or variabilities of climatic elements.

A climatic average or "mean" in the language of the climatologist is computed from records extending over a period of years. A mean for a particular 30-year period (e.g., 1931–1960 or 1941–1970) is called a "normal" by international convention. The normals used by the National Oceanic and Atmospheric Administration (NOAA) for climatological work are recomputed every 10 years. The first 10 years of data are dropped, and the most recent years of data are added to the record for such a recomputation. Values for the same periods of record are best for comparing the climates of different locations.

Sources of Data

About 40 million weather observations are made throughout the world every year. In the United States, observations are made around the clock at more than 275 National Weather Service offices by human observers and automatic recording instruments. Observations also are made in the United States at about 13,000 cooperative stations manned by volunteer observers. Since 1966, weather satellites circling the Earth at altitudes ranging from 500 to 1,000 miles have been taking pictures daily of cloud formations and snow fields around the globe and also have been sensing heat emissions from the Earth and its atmosphere. These and the observations taken by ships at sea, by instruments carried aloft by balloons, and by remote untended instruments on land and at sea by all nations make data available on daily weather conditions around the globe.

Much of this vast accumulation of weather records is stored at the NOAA National Climatic Center at Asheville, N.C. These archives include original chart rolls and recording forms, punched cards and magnetic computer tapes, and microfilm and microfiche records. Some records at this center date back to colonial times. Approximately 400 million cards had been accumulated by 1972; all or most of these card records are being transferred to magnetic tape records. These data have been processed and summarized; and records for individual stations, States, nations, and the world have been published. More than 3,000 pages of data and summaries are printed and distributed monthly by NOAA to National Weather Service offices, universities, public libraries, Government agencies, industrial, commercial, and marine interests, and the general public. These records enable NOAA to answer annually more than one million mail and telephone inquiries about weather and climate. A wealth of climatic data is routinely available to the thousands of subscribers to the publications.

Uses of Data

These data are used to determine the climate of a locality and can be used to assist agricultural, commercial, industrial, and other interests in their planning. For example, climatological data can be used to determine the best time to dry hay or raisins, to cure tobacco, or to plant or harvest crops. When the records for a location show mostly calm or light winds, a smoke-producing factory sited there could cause air pollution. Climatic records also can be used to determine the probability of the occurrence of hail, droughts, or freezes at any location.

Climatological summaries can be one of the factors considered in planning the location of resort hotels, airports, and business ventures, choosing the time and place for a vacation or for retirement, and for scheduling events that are weather dependent. They also are useful in designing heating or air-conditioning systems for a home, factory, theater, or office and for determining how much refrigeration will be needed to protect shipments of perishable foods. Masters of ships at sea use climatic charts of winds, ocean currents, and storm tracks in planning their routes.

Climatic records often are used as legal evidence in court cases to establish weather conditions at the time of an accident, a natural disaster, or a crime.

CAUSES OF CLIMATE

The underlying causes of weather and climate are heat from the Sun and the rotation of the Earth. The radiant energy of the Sun (solar insolation) and the constant rotation of the Earth about its axis serve to set up circulation patterns within the atmosphere. These circulation patterns carry heat and moisture from the Equator to the poles, across land and sea, and over flat land and mountains. Patterns of winds, rainfall, cloudiness, and temperature regimes tend to remain relatively steady at any given location on Earth. Weather sequences tend to follow the same pattern year after year; it is these patterns that determine the climate of a place.

The factors that cause climatic regimes are known as *climatic controls*. Briefly, climate is controlled by

latitude,
continentality and sources of moisture,
prevailing winds,
ocean currents,
elevation (altitude), and
mountain barriers (orography).

How each of these affects climate is described in the following sections.

Latitude

Heat from the Sun reaches the Earth after passing through approximately 93 million miles of space. The rays reaching the Equator appear to come from nearly directly overhead. At points nearer the poles, the Sun appears lower in the sky. The result is warm climates in the equatorial regions and successively cooler climates toward the poles—thus the higher the latitude, the cooler the climate.

Seasons modify the latitude effect because of the tilt of the axis of the Earth. The Earth's axis is tilted 23.5 degrees from a line perpendicular to the ecliptic (the plane that contains the Sun and the Earth's orbit around the Sun). Beginning about September 21 and ending about March 21, the north end of the axis points away from the Sun, so the rays from the Sun are more slanting in the Northern Hemisphere and more directly overhead in the Southern Hemisphere. In December and January, the Arctic is in continuous darkness, and the Antarctic is in continuous daylight; but the Sun is only 23 degrees above the horizon at the South Pole, so the antarctic summer is rather cool. An opposite situation occurs during the other half of the year.

The length of daylight, hence the length of time a location receives solar heat, increases as we move from the pole to the Equator during winter. During summer, the length of daylight increases poleward of the Equator, but the more slanted rays of the Sun keep the higher latitudes cooler than the low latitudes.

Continentality and Sources of Moisture

Land and water surfaces react differently to the incoming rays of the Sun. In general, land surfaces are heated rapidly by solar insolation; but the heat does not penetrate deeply, so land surfaces also cool rapidly. On the other hand, water warms up slowly, holds a much larger quantity of heat than the land surface, and cools slowly.

The net result is that the surface layer of air over the continents is warmer in summer and colder in winter than that over the oceans. Since warm air rises, permitting air from cooler areas to flow in to replace it, there is a net inflow of cool ocean air onto continents in summer and an outflow from the continents in winter; this is known as the *monsoon effect*. A somewhat similar situation exists in coastal areas where the land is colder at night and early morning and warmer later in the day than the adjacent water, resutling in land and sea breezes.

Sources of moisture such as oceans, gulfs, lakes, and other large bodies of water have a profound influence on the climate of an area. The amount of this influence depends primarily on air movement, mountain barriers, distances, and the areas of water bodies. These are the primary factors in the distribution of moisture over the world.

The effects of distance from a water source are that the interiors of continents (map 20) tend to be drier and hotter in summer and colder in winter than the coastal areas (maps 3 and 6); there also are greater differences between daily maximum and minimum temperature (maps 12 and 13). There are many exceptions to these generalized effects of continentality. The exceptions such as dry coastal areas and moist interiors result from the effects of other climate controls superimposed on the continentality effect.

Prevailing Winds

The differential heating of the Earth by the Sun is the main cause of wind systems. The equatorial regions receive considerably more solar heat per unit area than do the polar regions. Just as with the continentality effect, warm equatorial surface air rises and is replaced by cooler surface air flowing in from the poles. Thus the unequal heating of the Earth's surface together with its rotation produces a general global atmospheric circulation.

General Circulation

The global circulation, or worldwide wind pattern, dominates the flow of winds in the Earth's atmosphere. Surface winds in the Northern Hemisphere are arranged in three broad belts: the northeast trades[1] in the Tropics and Subtropics, the prevailing westerlies (from the west or southwest) in the middle latitudes, and the polar easterlies (from the northeast) in the polar region.

High- and Low-Pressure Areas

The rotation of the Earth about its axis causes winds to be deflected to the right in the Northern Hemisphere (i.e., a wind blowing from south to north is deflected or turned toward the east). Similarly, a north wind is turned toward the west. This deflection, called the Coriolis effect, results in the formation of large circulations of air called anticyclones or high-pressure areas. Between these Highs are cyclones or low-pressure areas that rotate counterclockwise or opposite in direction to the rotation of Highs. Air tends to flow inward toward Low centers and outward from high-pressure areas.

Air Masses and Storms

High-pressure areas (Highs) usually consist of large masses of air with homogeneous characteristics. Temperature and humidity are very much the same throughout any level in a high-pressure area. At an altitude of 10,000 ft., the temperature at the southern end of the High will be within 10 to 12 Celsius (18 to 22 Farenheit) degrees of the temperature at the northern end, which may be 1,500 miles away. Humidity also is distributed rather evenly. A High with such evenly distributed characteristics is called an *air mass*. Cold dry air masses move into the United States from Canada, generally traveling southeastward. Cool moist air masses generally travel eastward across the States from the Pacific Ocean. Warm moist air masses move in from the Pacific, the Gulf of Mexico, or the Atlantic. Each air mass brings its characteristic weather: cold and dry, cool and moist, warm and dry, or warm and moist.

Between Highs, low-pressure areas and weather fronts form. Most of what we consider to be "weather" occurs along these fronts, and the most active weather and storms occur around the low-pressure areas.

The Canadian Highs bring cool dry conditions. As they move into an area, they usually are preceded by showers along or adjacent to a cold front. The Pacific Highs, also preceded by fronts, are moister and somewhat warmer than the Canadian Highs.

Lows bring in warm humid air from the Pacific, the Gulf of Mexico, or the Atlantic. Lows are usually accompanied by widespread precipitation surrounding the circulation of the system. The average paths of these Lows mark the storm tracks across the country.

The migrating Highs and Lows occur more frequently, are more intense, and travel faster in winter than in summer. Average motion is 750 miles per day in winter and 500 in summer.

The air masses that prevail over an area determine its climate. For example, the Southeastern States are dominated in summer by a moist tropical air mass associated with a high-pressure area located offshore. The southerly winds on the west side of this High bring moist air from the Gulf of Mexico into these States. In winter, these States are invaded by Canadian air masses that bring cold fronts across the area about once every five days.

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[1] Winds are named for the direction from which they blow (e.g., northeast winds blow from northeast to southwest.)

Severe local storms, such as thunderstorms and tornadoes, and tropical cyclones up to hurricane intensity are superimposed on the general climatic pattern. Winds in the upper atmosphere tend to "steer" moving air masses at lower levels. The jet stream, a meandering current of air at the 30,000- to 50,000-foot level, moves air masses in a generally eastward direction. The jet stream is a controlling factor in day-to-day changes in weather.

Semipermanent Highs and Lows

Wind and storm patterns are strongly influenced by the locations and intensities of semipermanent high- and low-pressure areas. A semipermanent pressure area is one dominated by either high or low pressure (i.e., on the average, such an area will have either high pressure or low pressure). The Aleutian Low is the semipermanent pressure system that dominates the northern end of the North Pacific. This Low intensifies and expands in winter and weakens and moves to the northwest in summer. Its average central pressure in February is 999 millibars (mb) or 29.50 inches. The Pacific High, another semipermanent pressure system, intensifies and expands in summer. The average summer pressure at the center of this High is 1025 millibars or 30.27 inches at its center near 38°N, 150°W, about 1,600 miles west of San Francisco. In its summer position, this semipermanent Pacific High effectively blocks the passage of storms into the California-Oregon-Washington coastal area, steering them instead to the coast of British Columbia. In autumn and winter, this High becomes weak, and its center moves to the southwest. In this new position, it cannot block the movement of storms to the coast, so there is an increase in the frequency of storms reaching the Washington coast by September. By late November and December, storms reach the coast as far south as southern California.

The semipermanent pressure systems in the Atlantic are the Icelandic Low and the Bermuda (or Azores) High. Many of the storms associated with migratory low-pressure areas in the central and eastern United States tend to drift toward the Icelandic Low; the favored path of these storms is across the Great Lakes and along the St. Lawrence Valley. During summer, the Bermuda High has a marked effect on the Eastern United States. This High is strongest during summer when it lies off the east coast and brings a southerly flow of warm moist maritime air from the Caribbean Sea into the interior. On occasion, this warm moist air is carried into the Arizona-New Mexico area to which it brings welcome rainfall.

Ocean Currents

Well-established ocean currents have great effect on the climates of coastal areas. Perhaps the best known ocean current is the Gulf Stream that carries warm waters from the Florida Straits first northward along the Atlantic coast and thence northeastward and eastward to the British Isles. Without the Gulf Stream, Great Britain and Ireland and probably most of Western Europe would have a much colder climate akin to that of the Kamchatka Peninsula of eastern Siberia (at the same latitude as England). Winds blowing across this warm stream of water pick up heat and moisture and bring it over land both on the East Coast of the United States and over western Europe.

The Japanese Current is the major ocean current affecting the West Coast. This current reaches the west coast of the continent at about the latitude of the United States-Canada border. Here it branches: one branch, the Alaska Current, turns northward bringing a milder warmer climate to coastal British Columbia and Alaska; the other branch, known as the California Current, turns southward bringing cooler water along the shore of Washington, Oregon, and California. During winter, the Davidson Current moves in from southeast of the California Current, bringing warmer weather to the coast.

The United States East Coast climate is also affected by the cold Labrador Current which flows southward along the coast as far as Norfolk, Va. The presence of this current is responsible for frequent fogs over the coast.

Elevation (Altitude)

Temperature in the atmosphere decreases with increasing elevation. The usual rate of decrease (called the "lapse rate") is 3.3°F per 1,000 feet. In general, the climatic mean temperature of a high location is 3.3°F lower per 1,000 feet of elevation than that of surrounding lower altitude stations (fig. 1).

Mountain Barriers (Orography)

Not only do mountain ranges have colder temperature conditions at higher elevations but they also act as barriers to block the flow of prevailing winds and the movement of storms. Also air flowing upward on the slopes of a mountain barrier tends to drop much of its moisture on the windward side of the range. This is

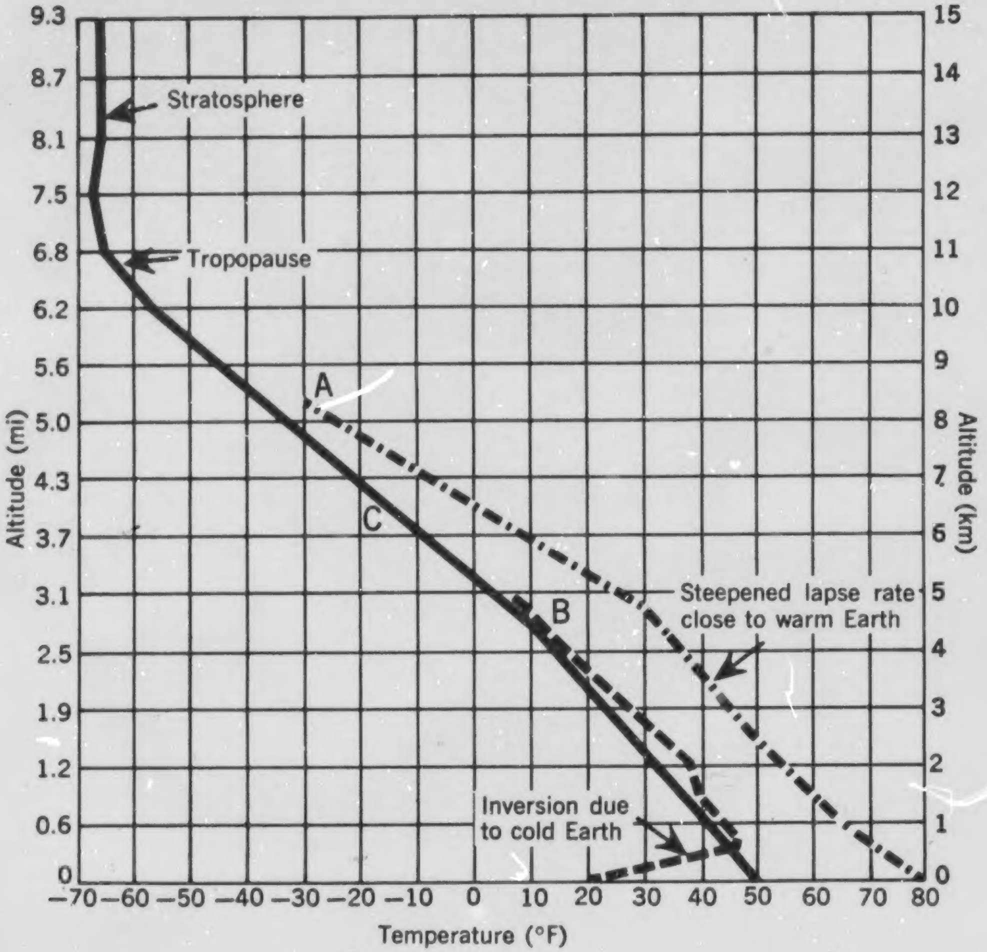

Figure 1.—Variation of temperature with altitude: (A) during a hot sunny day, (B) during a cold clear night, and (C) middle-latitude average

the orographic effect that is the reason for the deserts that lie to the east of the Coast Ranges and the Cascade-Sierra Nevada Ranges of California.

A very important physical feature of the mountain ranges in the conterminous United States is their orientation. Most are oriented in approximately north-south lines and tend to block the flow of the prevailing westerlies. Moisture-laden air from the Pacific is forced up the slopes of the Coast and Cascade-Sierra Nevada Ranges where it dumps most of its moisture. In the east, the Appalachian Mountains tend to block the flow of Atlantic air into the interior. Their orientation, on the other hand, permits the free passage of the cold arctic and polar air masses of Canada over the central and eastern two-thirds of the United States. This placement of mountain ranges and the lack of an east-west mountain barrier also permits the unhampered northward flow of warm maritime tropical air far northward into the interior of the continent. This zone of free flow through the center of the continent is the meeting place of cold and warm air masses; fronts and storms form in this area as the air masses clash. Weather activity is most marked here in the spring and fall.

Chapter 2

Geography and Climate

The United States including Alaska, Hawaii, Puerto Rico, and the Virgin Islands spans four climatic zones: Arctic, Temperate, Subtropic, and Tropical. Each of these broad climatic zones is subject to the modifications imposed by the climatic controls described in chapter 1. Aside from its latitude, the geography of a region probably affects its climate more than any other factor. The climate of each of the various regions of the United States is described separately in this chapter.

CONTERMINOUS UNITED STATES

The conterminous United States is defined as the 48 States south of the 49th parallel on the North American Continent. This part of the United States lies completely within the Temperate Zone.

The Atlantic and Pacific Oceans, the land masses of Canada and Mexico, and the Gulf of Mexico all influence the weather of this part of the United States. The geography of these States with its plains, mountain ranges, large drainage basins, lakes, and rivers strongly modifies the general Temperate Zone climate of the area. These states cover an area of 3,022,387 square miles, of which 47,661 square miles are the water surfaces of lakes, rivers, reservoirs, streams, and ponds.

The conterminous United States can be divided into seven physical regions, each of which is characterized by a more or less homogeneous climatic regime (map 1). These regions are (1) the Pacific Coast including plains, the Coastal Ranges, and inland valleys; (2) the Cascade-Sierra Nevada Mountains; (3) the Intermountain Plateau also known as the Great Basin; (4) the Rocky Mountains; (5) the Great Interior, Southern Plains, and Lowlands; (6) the Appalachian Mountains; and (7) the Middle and North Atlantic Lowlands.

The principal climatic features of these regions are described in separate sections of this chapter. Details of specific climatic elements are given in later chapters.

Pacific Coast Region

The Pacific Coast region consists of the coastal plains, the Coastal Ranges, and the adjacent inland valleys of Washington, Oregon, and California. The coastal plains vary in width from a few miles to about 50 miles. In certain places between northern California and the Canadian border, the coastal plains disappear; here the Coast Ranges meet the sea. The narrow and relatively low Coast Ranges extend along the length of the west coast from Canada to Mexico. Altitudes range from 1,000 to 3,000 feet, except for occasional elevations in excess of 5,000 feet in the Olympic Mountains of Washington and in extreme northwestern and extreme southwestern California. San Francisco Bay, the Columbia River, and Puget Sound mark the main breaks in the ranges. The principal inland valleys (the valley of the Puget Sound area, the Willamette Valley, and the Sacramento-San Joaquin Valleys) are sheltered from the ocean by the Coast Ranges.

The Pacific Coast has a Mediterranean type climate with dry summers and mild wet winters. Two factors are responsible for this mild climate. In summer, the strong Pacific High steers storms to the north of the region. When the High weakens in winter, storms of greater intensity hit the coast more frequently. The prevailing westerly winds are cooled in summer by passing over the cool California Current and the colder waters nearer shore. The cold inshore waters are upwelling of subsurface water that replaces warmer surface water "blown away" by the prevailing winds. In winter, the cool ocean winds are warmed by their passage over the Davidson Current that carries warm water northward along the coast. The famous California fogs are caused by the cooling of warm ocean air by the colder ocean currents along the shore. As the warm moist air carried by the prevailing winds cools to its condensation point, low clouds and fog form. Fog also forms over the inland valleys when the warm winds from the ocean move in over the cold land surface.

The Pacific Coast remains cool except in the inland valleys that are dry and hot during the rainless summer. These inland valleys are cut off from the cool ocean winds by the Coastal Ranges. Although the winds are generally westerly throughout the year, occasional shifts to easterly winds in summer bring hot, dry weather even to the coastal areas. These are periods of extreme forest-fire danger. In winter, these easterly winds bring in frequent cold spells to the coast. Although the Cascade-Sierra Nevada Ranges protect the coast from the severe winter weather of the interior, very cold air masses sometimes spread over the mountain barriers or move down the coast from the northwest, bringing freezing temperatures and even snow to coastal regions. The extreme south coast experiences freezes once every 5 to 10 years.

Cascade-Sierra Nevada Mountains Region

The Cascade-Sierra Nevada Ranges form a continuous chain of mountains that extend from the Canadian border to extreme southern California. The Cascade Mountains lie almost north-south across central Washington and Oregon and connect with the Sierra Nevada in northern California. In California, the Sierra Nevada Range is east of the great inland valleys and joins the Coast Ranges in southern California. This continuous chain of mountain varies in width from 20 to 70 miles and is generally 8,000 to 10,000 feet high. It acts as a barrier to the free movement of air masses from both east and west. During the colder portion of the year, storms moving eastward from the Pacific are forced up this barrier (orographic lifting). This forced lifting causes cooling, the formation of clouds, and, eventually, precipitation of most of the moisture in the air mass in the form of rain or snow on the windward (western) side of these ranges. As the air moves down the eastern side, it warms somewhat by compression; precipitation is light or absent because most of the moisture has been precipitated on the windward side.

The heavy winter rains and the snow pack at higher elevations of the Cascade-Sierra Nevada Ranges are the source of most of the water supply for the region. Water collected in reservoirs is used for domestic, industrial, and agricultural purposes during the nearly rainless summer.

Weather in the region is dominated by the usually mild Pacific air brought in by the prevailing westerlies. Temperatures are cool because of altitude. The summers are generally fair, sunny, and pleasant; the winters are moderately cold with frequent heavy snowfalls. Summer and winter resorts are numerous.

Intermountain Plateau Region

The Intermountain Plateau lies between the Cascade-Sierra Nevada Ranges and the Rocky Mountains. Many small mountain ranges lie across this region, and two major river systems cut into the plateau—the Columbia-Snake River System in the north and the Colorado River in the east-central and the southwest. Elevations are generally above 5,000 feet, except for the areas in the southwest where the deserts are near or locally below sea level.

The Cascade-Sierra Nevada Ranges either modify the mild moist air masses reaching the region from the Pacific or bar their entrance. To the east, the Rocky Mountains shield the region from frequent incursions of warm moist air from the Gulf of Mexico and from most of the cold air that sweeps south from Canada onto the Great Plains.

The Intermountain Plateau is the driest region of the United States. Most of its moisture comes from winter snowfall. Water is stored in reservoirs and in snowfields on the mountains of the region. The elevation of the plateau and the low humidity favor strong daytime heating and strong radiational cooling at night, giving this area the greatest daily range of temperature in the country (maps 12 and 13).

Winters are quite cold because of the prevalence of cold air masses in the northern part of the region; the generally high elevation also contributes to the lack of warmth. In winter, the southwestern deserts are somewhat warmer than the rest of the region. Summer weather is mostly fair, dry, and sunny on the plateau, with higher temperatures in the valleys and hot conditions in the deserts.

Rocky Mountains Region

The high ranges of the Rocky Mountains extend southward from Canada into northern, central, and eastern Idaho, western Montana, western and central Wyoming, northeastern Utah, western and central Colorado, and north-central New Mexico. Nine-tenths of the conterminous United States with elevations above 10,000 feet lies within this region; three-fourths of this high area is contained within Colorado. The crest of the Rocky Mountains forms the Continental Divide, which separates the Pacific Drainage Basin from the Atlantic-Gulf of Mexico Drainage Basin.

Precipitation is much more frequent in the mountains than in adjacent semiarid areas because of their orographic effect on the air masses that move across them. Rain and snow falling in the Rocky Mountains are the source of most of the water supplies both for the region itself and for the adjacent semiarid areas. Most of the water used for irrigation, industry, and home needs in western Arizona and southern California (including the city of Los Angeles) comes from the Colorado River, which is fed by rain and the melting snow pack of the Rocky Mountains. Water from these mountains also feeds the Rio Grande, Arkansas, Platte, Missouri, and Columbia Rivers. The Columbia River, also fed by water sources in the Cascades, usually reaches its highest rate of flow during the warm dry seasons (spring and early summer) when melt from the snow pack is at its greatest. The Columbia supplies water to Idaho, Washington, and Oregon.

Because of high elevations, winter in the Rocky Mountains is very cold, particularly along the eastern slopes where there are frequent incursions of cold air masses from Canada. Summer is cool because of the high elevations and the influx of cool Canadian air. Valleys and canyons occasionally become quite hot during summer. This region has many popular recreation areas and National Parks.

Great Interior, Southern Plains and Lowlands Region

This region extends from the Rocky Mountains to the Appalachian Mountains, from the Canadian border to Mexico and the Gulf of Mexico, and from the southern extremity of the Appalachian Mountains eastward to the Atlantic Ocean and southward to the Florida Keys. Because there are no climatic barriers, climate changes across the region are gradual; hence it is possible to consider the Great Interior, Southern Plains and Lowlands Region as one vast climatic region. Differences in climate across the region are controlled primarily by latitude, general air mass and storm movements, elevation, and distance from moisture sources.

The highest elevations are found in the western part of the Great Plains where heights range from 3,000 to 4,000 feet along the foothills of the Rocky Mountains. Elevations in the Minnesota-upper Lake Superior area range from 600 to 1,400 feet. Other elevations are 200 to 500 feet in the northwestern New York-St. Lawrence River area, 250 to 700 feet in the central Mississippi Valley, and 1,000 feet at the southern end of the Appalachian Mountains. Elevations are near sea level along the Gulf of Mexico and South Atlantic coasts.

With the exception of the Gulf of Mexico and South Atlantic coastal areas and Florida, the climate is predominantly of the continental type, with cold winters, warm to hot summers, and great extremes of temperature. Along the gulf and South Atlantic coasts, the modifying effect of the Gulf of Mexico and the Atlantic Ocean contributes to relatively mild and humid winters and rather uniformly very warm and very humid summers. Southern Florida has a subtropical climate; its weather is dominated by the northeast trade winds.

The northern and central portions of this region are invaded by cold dry polar or arctic air masses frequently in winter and less frequently in summer. Occasionally, these cold air masses reach the gulf and South Atlantic coasts bringing freezing weather and frost conditions as far south as central Florida several times each winter. Warm moist maritime air moves northward into the interior of the region rather often during the summers and less frequently during the winters. Circulation around low-pressure areas moving toward the east or northeast across this region or across southern Canada is one of the causes of this northward flow of warm gulf air into the region. The contrast between the warm continent and the cooler oceans during the summer months causes air to flow northward over the region (monsoon effect). The wind around the western side of the Bermuda high-pressure area, which intensifies in summer, contributes to this northward flow of air. In winter, a reverse monsoon effect caused by the outflow of cold air from the interior of the continent contributes to the southward movement of cold air masses across the region.

Although weather conditions generally are pleasant, this region experiences many violent local storms in the form of tornadoes, severe thunderstorms, and hail storms. A few heavy snowstorms, ice storms, and blizzards occur each winter, particularly in the northern and central parts of the region. The winter cold waves that sweep the interior regularly sometimes spread as far south as the Gulf Coast and occasionally reach central and southern Florida. Squall lines in advance of cold fronts, and individual thunderstorms and tornadoes bring very strong sometimes destructive winds particularly in spring and summer. The gulf and Atlantic coasts are subject to the destructive forces of Atlantic hurricanes. These tropical storms bring very high tides (storm surges), strong winds, and heavy rains; occasionally loss of life and property is caused by the destructive force of winds and by the coastal and inland flooding associated with these tropical storms.

This great agricultural region has as its principal source of moisture the northward flow of air from the gulf. Southerly and easterly winds from the Atlantic bring moisture and precipitation to the Atlantic States. To the west, the area on the eastern slopes of the Rocky Mountains is considerably drier than the rest of the region because the mountains block the movement of moisture-bearing winds from the west. Westerly winds flowing down the eastern slopes of the mountains are usually dried out by compression effects.

Appalachian Mountains Region

The Appalachian Mountains extend from northern Georgia north-northeastward to northwestern Maine. These mountains are about one-third as high as the western mountain ranges, averaging 2,000 to 4,000 feet above mean sea level, and so do not bar the passage of weather systems as effectively as the Rocky Mountains and the Cascade-Sierra Nevada ranges. Cold fronts and storms moving in from the west are forced upward along the western slopes of the Appalachian Mountains; this orographic lifting is sufficient to cause a considerable amount of rainfall during the warm months and heavy snowfall in winter. A similar effect occurs on eastern slopes when fronts or storms move northward or westward from the Atlantic. Many tropical storms and dissipating hurricanes expend their energy and remaining rainfall on these mountains, particularly in the southern portions. Weather over the region varies greatly from place to place because of irregular terrain. Valleys are warmer than higher elevations, but temperatures in general range about 5° to 12°F lower than in surrounding geographic regions.

Middle and North Atlantic Lowlands Region

The Middle and North Atlantic Lowlands Region is situated between the Appalachian Mountains and the Atlantic Ocean north of the South Carolina-North Carolina boundary. These coastal lowlands vary in width from about 200 miles in the south to 40 miles in the southeast New York-western Connecticut area, and then broaden again to about 150 miles in Maine.

Although the region is partially sheltered from the extremes of weather that occur west of the Appalachian Mountains, most air masses, fronts, and storms cross these mountains with little change in intensity. So the climate of the region is very similar to but somewhat less severe than that of the interior.

Lows moving toward the region from the interior sometimes are forced by the mountains to swing northeastward to the St. Lawrence Valley instead of moving over the Atlantic lowlands. The mountains also protect the region from some of the cold outbreaks pushing from Canada southward across the Great Lakes. The mountains force the shallow masses of cold air to move south along the western slopes. Sometimes, when the push is strong enough, the cold air breaks around the southern end of the mountains and spreads over South Carolina, Georgia, and parts of Florida. When this happens, the temperatures in these Southern States are as low or lower than those in the Atlantic Seaboard States to the north.

Storm systems moving northward from the Gulf of Mexico or along the Atlantic coast, and cold fronts and storms moving over the mountains from the west bring most of the precipitation that falls in the region. In winter, arctic and polar air masses follow cold fronts into the region from the west, bringing snow showers and very low temperatures. Storms along the Atlantic coast also can bring heavy snowfall.

Winters are somewhat warmer near the coast than farther inland because the warmer waters of the Atlantic furnish heat to the lower layers of the atmosphere. Summers along the seacoast and in the mountains to the west are cooler than those of the inland lowlands, so the beaches and mountain resorts of these areas are used by millions to escape the heat.

ALASKA

The area of Alaska is 586,400 square miles, an area almost two and one half times that of Texas. About one-fifth of Alaska lies north of the Arctic Circle, with its northernmost extremity at Point Barrow (71°18′N, 156°47′W), which is located 1,291 miles south of the North Pole. Most of Alaska is located on a huge extension of North America. The State includes the Aleutian Islands, a chain that stretches approximately 1,600 miles west-southwestward toward the Kamchatka Peninsula in Siberia. The southeastern part of Alaska includes numerous islands and a narrow coastal strip extending about 550 miles southeastward between the Pacific Ocean and the Canadian Province of British Columbia. The islands and much of the mainland are rugged mountainous terrain. Two main ranges lie roughly east-west across the State: the Brooks Range in the north and the Alaska Range in the south. The Yukon River flows westward between these ranges and empties into the Bering Sea near 63°N.

The windswept coastal plains and lowlands of western and northern Alaska are almost entirely tundra. Many large and countless small lakes are scattered throughout the State. Several glaciers cap the mountains of southeastern and south-central Alaska, which also is the site of Mt. McKinley, the tallest (20,320 ft) peak in North America.

The southeastern, southern, and southwestern coastal areas and the coastal islands have a marine type of climate, with mild temperatures for these high latitudes. There is much cloudiness, high humidity, frequent fog and drizzle, abundant precipitation, and almost constant strong wind. The central and western part of the Aleutian Islands chain is one of the stormiest regions of the world. Storms associated with the semipermanent Aleutian Low form and move eastward along the island chain and along the south coast. In summer these storm systems are weaker than in winter and are displaced to the northwest of their winter position. During the summer the semipermanent Pacific High strengthens and causes a steady flow of onshore winds over southeastern Alaska.

Except along the Arctic coastal plain, the Alaskan lowlands can be farmed during the short summers Although the sun is low in the sky, there is almost continuous daylight over much of the Arctic. Summers here are relatively mild, reaching the 60s and 70s (°F) in July and August. The highest summer temperatures in Alaska are found in the interior in the valleys of the Tanana and the upper Yukon rivers. During the winter, the coastal lowlands along the Bering Sea experience subarctic weather, especially after the sea freezes.

During the summer the climate over the inland mountains is generally cooler than that of the lowlands and the great river valleys. During the winter both mountains and lowlands experience frequent storms and almost continuous strong winds.

The climate of the Brooks Range and the plains to the north is much more severe than that of the rest of Alaska. The range is snow covered year round, and minimum temperatures average lower than −20°F during the winter months. On the plains to the north, arctic conditions prevail. During the winter, when the Beaufort Sea is frozen, temperatures are extremely low and the area is continuously snow covered. The melting of the Beaufort Sea and the continuous sunlight during the summer months moderate conditions somewhat. This is a permafrost region; it is reported that the ground in the Point Barrow area is frozen to a depth of 1,330 feet.

HAWAII

The State of Hawaii, a string of 6 large islands, 2 small islands, and several very small islands is situated in the tropical part of the eastern North Pacific some 2,100 miles west-southwest of California. These islands, scattered along a line roughly from east-southeast to west-northwest, stretch across 430 miles. The total land area is 6,434 square miles, or roughly one third larger than that of the State of Connecticut. The island of Hawaii occupies two-thirds of the entire area of the State. Its location between 19° and 22°N. and 154° to 160°W places the State in the northern part of the Tropical Zone. Here solar insolation is strong, but the heat effect is kept at moderate levels by the prevailing northeast trade winds from over the Pacific. The modifying influence of the sea is directly responsible for the relatively small seasonal temperature changes in Hawaii.

Marine influence on the climate of these islands is great. More than half of the total area of the islands is within 5 miles of the sea, and so is subject to the modifying influences of the surrounding waters. Climatic conditions in the mountains, especially those on the islands of Hawaii and Maui, are quite different because of the elevation and the orographic effects of the mountains on the moisture-bearing trade winds.

Temperatures in this island chain average only 4° to 8°F higher in summer than in winter, despite a 50 percent increase in solar heating and two and one-half more hours of sunlight per day. By way of contrast, temperatures at Washington, D.C. are 40°F higher in summer than in winter, with a 100 percent increase in solar energy, and five and one half more hours of daylight.

Rainfall in the islands varies tremendously from place to place. The normal total annual precipitation ranges from less than 10 to more than 400 inches. Frequent rains, ranging in intensity from light to very heavy, fall on the windward sides of the mountains. A 40-year mean world record of 460 inches of rainfall annually was set at Mt. Waialeala on the island of Kauai. The leeward sides of both islands and mountains are much drier than the windward sides.

Major storms associated with cold fronts, tropical eddies, or low pressure areas do pass over the Hawaiian Islands, but rather infrequently. Storms occur mainly between October and March. Few tropical storms have ever affected the islands.

PUERTO RICO AND THE U.S. VIRGIN ISLANDS

Puerto Rico, the easternmost large island of the West Indies, lies about 1,000 miles southeast of Miami and 1,600 miles south-southeast of New York. The main island of Puerto Rico is 40 miles wide and 109 miles long and has an area of 3,534 square miles. Three smaller islands included in the Puerto Rico group cover 50, 40, and 10 square miles respectively. The U.S. Virgin Islands group, which lies just to the east of Puerto Rico, contains 3 major islands covering a combined area of 150 square miles, and about 50 very small islands and cays.

Situated between 17°30′ and 18°30′N and 64°30′ and 67°30′W, these islands experience much the same kind of weather and climate as Hawaii. Total annual precipitation ranges from about 40 to 100 inches per year, much less than the extremes in Hawaii. The main difference in climate between Hawaii and the less mountainous Puerto Rico-Virgin Island region is that the latter is affected quite frequently by tropical cyclones, a few of which reach hurricane proportions.

Part II: General Summaries

The chapters that follow are summaries describing climatic variables over the United States, both from a statistical and a historical viewpoint. Numerical values are given to describe each variable, the effects of normal and extreme weather conditions on human activity are described, and the uses of climatic information are discussed. Temperature, precipitation, and storms are described in separate chapters. Information on winds, floods, droughts, fog, relative humidity, sunshine, and atmospheric pressure is given in the final chapter.

Chapter 3

Temperature

WINTER AND SUMMER TEMPERATURES

In the **conterminous United States**, the winters are the coldest in the extreme northern interior and in higher elevations of the mountains and are the warmest in extreme southern areas, particularly along the southern California coast, along the Gulf and South Atlantic coasts and in southern Florida (maps 2, 3, 10, and 11). The coldest section is the northeastern North Dakota—northwestern Minnesota area where in January the afternoon highs average 10° to 15°F and the morning lows −5° to −10°F. In the northern and central Rocky Mountains, midwinter daily highs average 20° to 25°F and lows −5° to 5°F at the higher elevations. There is a general increase in average daily temperature southward. Average daily highs of 55° to 65°F and lows of 40° to 45°F occur along the southern California coast, 65° to 68°F and 45° to 50°F along the middle gulf coast, and 75° to 80°F and 60° to 65°F in extreme southern Florida.

At higher elevations of the western mountains, particularly the Rockies, temperatures drop to 0°F or below on 50 or more days a year and to freezing or below on from 180 to 250 days (maps 4 and 5). In the high Rockies, temperatures remain at 0°F or below a total of 10 days or more per year and below freezing 100 days or more in a year. These conditions are true also from northern Montana eastward over North Dakota, northern Minnesota, extreme northern Wisconsin, Upper Michigan, and parts of northern and west-central New England. During an average year, 0°F readings are reported as far south as the southern Sierra-Nevada in California, east-central Arizona, southern New Mexico, central Oklahoma, Tennessee, and south-central New Jersey. Zero temperatures have been observed as far south as northern Florida only in the Februarys of 1835 and 1899, but never on the Louisiana or Texas coasts, nor in the coastal areas, Central Valley, and extreme southeastern sections of California, nor in extreme western Arizona.

The number of days with freezing temperatures decrease southward, normally ranging from less than 2 to about 5 mornings a year in the area from extreme southern Texas eastward along the gulf coast to and across the central Florida Peninsula, with none reported from Key West, Fla. Along the Pacific coast, freezing temperatures are reported about 10 to 20 days a year in the northern portion and fewer than 10 days a year in the southern portion. Freezes occur less than once in 2 years along the extreme southern coast of California and in San Francisco and Los Angeles, and only about once in 10 years at San Diego.

In summer, the warmest sections are interior valleys and desert areas of the far Southwest, the southern Great Plains, and the Deep South, while the coolest areas are the extreme northern districts, the mountains, and the northern coastal areas. (See maps 6, 7, 10, and 11). Midsummer temperatures are highest in southwest Arizona and extreme southeast California where they average from 100° to over 110°F in the afternoons and 75° to 85°F in the mornings. In the southern Great Plains maximum daily temperatures average about 95° to 98°F and minimums 68° to 74°F. In the Deep South, average maximums are 90° to 94°F and minimums 68° to 72°F. Average daily summer temperatures decrease northward to maxima of 80° to 90°F and minima of 55° to 60°F in the northern Great Plains. Highs average 70° to 80°F and lows 40° to 50°F in the high elevations of the central and northern sections of the western mountains.

In southwest Arizona and extreme southeast California, temperatures usually rise to 100°F or above on from 90 to 110 days annually (over 140 days annually, in Death Valley, Calif.), and to 90°F or above on from 120 to over 180 days. (See maps 8 and 9). The annual number of days with afternoon highs of 90°F or above also exceeds 120 in the central Rio Grande Valley and in the interior sections of the Florida Peninsula. Texas, Florida, and a narrow strip of land a short distance from the central part of the gulf coast experience over 90 days annually when the temperature reaches 90°F or above. The annual number of days with 90°F and above decreases northward to about 30 days a year at a line extending from Montana eastward through Iowa, southern Ohio, and central Virginia, and to less than 5 days a year in Upper Michigan, the high Appalachians, north Atlantic coastal areas, the high elevations of the western mountains, and along the Pacific coast. Temperatures have reached or exceeded 100°F in all states, except on high mountains and in many northern and middle Pacific coastal areas where maxima have not exceeded 90°F. The extreme high temperatures during a year at the 10,000-foot elevation in the Rockies are about 85°F; this is equal to the record high temperature at Eureka on the northern coast of California. At the 14,000-foot elevation the highest recorded temperature is about 65°F.

In comparison to the above, the mean annual temperature of the conterminous United States is 53.2°F. This figure is based on 77 years of areal weighted averages.

In **Alaska**, winters are coldest in the northern and interior areas and warmest in the southwestern, southern, and southeastern islands and coastal areas. In January, the normal daily highs and lows at Point Barrow are −13°F and −25°F; at Fairbanks, −2°F and −22°F; at Nome, 11°F and −3°F; in the Anchorage area, 19°F and 4°F; on the central south coast, about 30°F and 20°F; and on the extreme southeast coast, near 40°F and 30°F. The average annual number of days with 0°F or colder and with freezing or below are 169 to 324 days, respectively, at Point Borrow; 132 and 226 days at Fairbanks; 89 and 240 days at Nome; 41 and 201 days at Anchorage; and 9 and 149 days at Juneau. Usually temperatures remain at freezing or below all day on 256 days a year at Point Barrow, 162 days at Fairbanks, 174 days at Nome, 121 days at Anchorage, and 50 days at Juneau.

Summers in Alaska are warmest in southeast, south, and southwest coastal and valley areas and in the central and southern interior valleys, and coldest on glaciers and snow-covered mountains, particularly at high altitudes in northern interior areas. The July normal daily high and low temperatures are 63°F and 48°F at Juneau, 66°F and 50°F at Anchorage, 72°F and 48°F at Fairbanks, 55°F and 44°F at Nome, and 45°F and 33°F at Point Barrow. The temperature reaches 70°F or higher on 20 days a year at Juneau, 12 at Anchorage, 51 at Fairbanks, 2 at Nome, and about once in 3 years at Point Barrow.

In **Hawaii**, the normal daily high and low temperatures along the east (windward) coasts of the Islands average 85°F and 70°F in August and September and 79°F and 64°F in January and February. On the east side of the mountains at the 4,000-ft elevation, highs and lows average 70°F and 55°F in July and August and 65°F and 50°F in January and February. In the interior lowland to the west or leeward of the mountains, the normal daily highs and lows are about 88°F and 70°F in August and near 81°F and 61°F in January. Temperatures above 95°F are extraordinarily rare even in dry and relatively cloudless areas, such as the western and interior lowlands leeward of the mountains, where temperatures in the low 90s may be reached several days during the year. Except for these leeward areas, temperatures of 90°F and above are so unusual that several years may pass before one is experienced. Freezing occurs only above the 4,000-foot level on the mountains in winter. The highest and lowest temperatures on record are 100°F at Pahala (elevation 850 ft) on Hawaii Island, April 27, 1931, and 14°F at Haleakala (elevation 9,750 ft) on Maui Island, January 2, 1961.

In **Puerto Rico**, the north and east coastal areas have normal daily highs of 86° to 90°F and lows of 71° to 75°F from July to September, and highs of 80° to 84° and lows of 64° to 70°F from January to March, the warmest and coolest periods of the year. On the central south coast the highs are usually 89° to 90°F and the lows near 72° to 75°F from June to October, and 86° to 87°F and 65° to 69°F from January to March. Elsewhere at low elevations, highs and lows average about 88° to 91°F and 65° to 70°F from June to September, and 82° to 87°F and 60° to 64°F from January to March. On the high ridges, the highs average 75° to 83°F and the lows 61° to 66°F from June to October, and 70° to 77°F and 54° to 59°F from January to March. Temperatures usually reach 90°F or above on from 2 to 100 days a year in the northern, eastern, and western coastal areas, depending on exposure to the wind and nearness to the water, on over 200 days in sheltered low areas in the interior and on the southern coastal plains, and on 1 day or less a year in the higher interior areas. Temperatures may occasionally exceed 100°F. The highest and lowest temperatures on record are 103°F and 40°F.

In the **Virgin Islands**, temperatures average 86° to 89°F in the afternoons and 72° to 78°F in the early mornings from June to October and 82° to 85°F and 67° to 73°F from January to March. Temperatures normally reach 90°F or above on from 2 to 30 days a year in coastal areas and about 100 days in sheltered interior low areas. Neither freezing temperature nor frost has ever been reported in Puerto Rico or the Virgin Islands.

SPRING AND AUTUMN TEMPERATURES

These seasons of transition often have short periods reminiscent of the cold of winter and warmth of summer. They are the most pleasant seasons of the year in the southern States, and there is much fine weather over the rest of the conterminous United States. Autumns are noted for the occasional occurrence of Indian summer weather which favors outside activities, particularly the completion of harvests.

The most rapid warming of the year normally occurs about mid-March to mid-April and the most rapid cooling about mid-October to mid-November. This is caused by the rapid increase in intensity and duration of sunshine in spring and the rapid decrease in autumn. The normal increases in temperature and length of daylight in the 30-day period from about mid-March to mid-April are about the same as the decreases during the 30-day period from about mid-October to mid-November. Increasing northward, these 30-day changes amount to about 8° to 12°F and about 1 hour in daylight at the latitude of south-central Texas, 18° to 22°F and about 2 hours along the northern Great Plains-Canadian Border, and 22° to 25°F and 3½ hours in the middle Yukon Valley of Alaska. Temperature changes are much smaller in coastal and island areas because of the moderating effect of nearby water surfaces. In contrast, the changes in temperature and length of daylight during the midsummer month of July and the midwinter month of January generally amount to only a few degrees of temperature, and a few minutes of time.

With respect to temperature, the true 4-season year occurs across the middle portion of the country east of the Rockies. In extreme northern and mountainous areas, the cold of winter persists longer than the warmth of summer, while in extreme southern areas, summerlike weather prevails longer than winter weather. In the coastal areas of California, the mid-summer heat persists about 1 month longer than elsewhere in the conterminous United States. This also is true in Hawaii, Puerto Rico, and the Virgin Islands.

Along the Pacific coast, the prevailing ocean winds make both spring and autumn appear to last longer than summer and winter. In Alaska, the rapid increase to long days and then the equally rapid decrease to short days cause relatively sharp seasonal transitions between the long period of severe winter cold and the relatively short period of moderate summer warmth; consequently, spring, summer, and autumn appear as short seasons. Hawaii, Puerto Rico, and the Virgin Islands, which lie in tropical waters, are generally considered to have only warm and cool seasons.

TEMPERATURE RANGE

The daily range of temperaure is the difference between the lowest temperature, which usually occurs about sunrise, and the highest temperature, which generally occurs in midafternoon. A large temperature range indicates a continental type climate and a small temperature range a marine type climate. The mean daily range is 20° to 30°F over the interior portion of the conterminous United States during the warmer part of the year and a few degrees less during the colder half of the year. (See maps 10 and 13). The greatest daily range is found during the summer in the high plateau and high valley interior areas, particularly in the intermountain region of the Far West where the thinner atmosphere and generally clear skies favor strong solar insolation during the day and rapid radiational cooling at night. Reno, Nev., at an elevation 4,400 feet, has a mean daily July range of 47°F, one of the largest in the country.

In contrast, the mean daily range of temperature is about 10° to 15°F throughout the year on the Pacific, Gulf, and Atlantic coasts. This is caused by the moderating effects of the land and sea breezes and the movement of milder air from over water areas, particularly along the Pacific coast where the prevailing wind comes from the ocean. The mean daily range is about 10°F at San Francisco, Galveston, and Miami Beach, and 8°F on the Florida Keys. In Alaska, Hawaii, and Puerto Rico, the mean daily range of temperature is about 8° to 15°F in coastal areas and about 20° to 25°F in interior sections.

The mean annual range of temperature, the difference between the mean temperatures of the warmest and coldest months, varies from 65°F in northeastern North Dakota and northwestern Minnesota to 10°F on the central Pacific coast, and is less than 15°F in the Florida Keys (map 14). The mean annual *extreme* range in temperature, the difference between the extreme high and low temperatures during the year, is 40° to 70° along the Pacific coast and in southern Florida, near 70°F along the Gulf coast, 75° to 80°F on the middle Atlantic coast, and increases inland to 130° to 135°F in the northern Great Plains. In Alaska the mean annual extreme range is about 40°F on the outer Aleutian Islands, near 80°F along the Gulf of Alaska, about 105° to 110°F on the Arctic Ocean and Bering Sea coasts, and increases to 135°F inland in the east-central interior. Hawaii has mean annual extreme ranges of about 27° to 40°F in coastal areas and 40° to 50°F in the interior. In Puerto Rico these values are 25° to 32°F in coastal areas and about 30° to 45°F in the interior. The all-time extreme temperature range, i.e., the difference between the highest and lowest temperatures of record for the conterminous United States is 204°F (high, 134°F; low −70°F); for the United States as a whole it is 214°F (134°F, −80°F).

Temperatures may change very little during a period of several days of cloudy, foggy, rainy weather. On the other hand, sharp changes in the weather pattern, such as the passage of a strong cold front, the development of downslope winds, or the occurrence of a thunderstorm on a hot afternoon may produce unusually large changes in temperature in short periods of time. Some extreme cases are: a rise of 49° in 2 minutes from −4°F at 7:30 a.m., to 45°F at 7:32 a.m., January 20, 1943, at Spearfish, S. Dak.; a fall of 47°F in 15 minutes from 55°F at 7 a.m. to 8°F at 7:15 a.m., January 10, 1911, at Rapid City, S. Dak.; a fall of 100°F in 24 hours from 44°F to −56°F, January 23–24, 1916, at Browning, Mont.; a fall of 66°F in 8 hours from 76°F to 10°F, November 11, 1911, at Kansas City, Mo.

TEMPERATURE EXTREMES

The highest air temperature so far observed in the United States was 134°F, recorded on July 10, 1913, at Greenland Ranch (elevation 178 feet below sea level) in Death Valley, California (tables 1 and 3). The world record at Azizia, Libya, was 136°F on September 13, 1922. The highest temperature ever recorded in Alaska was 100°F at Ft. Yukon, June 27, 1915. The lowest temperature observed in the United States was −79.8°F at Prospect Creek Camp, Alaska, at elevation of 1,100 feet, on January 23, 1971 (tables 2 and 4). The world record low temperature so far is −126.9°F., (−88°C), August 24, 1960, at Vostok, a Russian Station in Antarctica, at an elevation of 11,440 feet. In the conterminous United States the lowest recorded temperature is −69.7°F which occurred at Rogers Pass, Mont., at an elevation of 5,470 feet, on January 20, 1954.

LOCAL TEMPERATURE VARIATIONS

Temperatures may differ considerably from point to point over short distances, particularly in mountainous terrain. These variations usually are due to differences in altitude, slope of land, type of soil, vegetative cover, bodies of water, air drainage, and urban heat effects.

An increase in altitude of 1,000 feet generally causes a decrease of 3.3°F in the average annual temperature. An extreme case exists in the Grand Canyon area of Arizona between Inner Canyon, elevation 2,500 feet; and Bright Angle, elevation 8,400 feet, which is 5,900 feet higher and 5 miles away. The normal daily highest and lowest temperatures in July are 106°F and 77°F at the former and 78°F and 47°F at the latter, and, in January, 55°F and 37°F against 37°F and 15°F.

Because of the daily motion of the sun, an eastern slope will be warmer in the mornings and colder in the afternoons than a western slope; a southern slope will remain relatively warm all day, while a northern slope will remain cool.

At night, especially on clear, calm nights, air near the ground cools because of radiative cooling. The cold air is heavier so if the land is sloping the cold air will drain off and flow to lower elevations. At the original elevation, the cold air will be replaced by warmer air. Knowledge of this effect in hilly areas is used by farmers who plant hardy vegetation in the bottom of the valleys and the more tender vegetables and fruits in the warmer belt just above.

Bare, dry soil will heat and cool more rapidly than a heavy, clayey, wet soil, or a soil covered with vegetation. Light colored surfaces will be cooler because they reflect a large portion of the incoming solar radiation, while dark surfaces will be warmer because they absorb much of the solar heat.

Bodies of water, such as the Atlantic and Pacific Oceans, the Gulf of Mexico, the Great Lakes, and to a slight extent the more than 50,000 small lakes from the eastern Dakotas to Maine, have a moderating effect on adjacent land areas. This effect varies, depending on wind, topography, and size of the water area.

Cities and industrial areas generally average a few degrees warmer and experience less extreme temperatures than the adjacent countryside. This is due to trapping of solar heat in the city by the complex of buildings, sidewalks, and streets, heat produced in domestic and industrial furnaces, stoves, and incinerators, and retention of much of this heat by the blanketing effects of smoke, gases, dust, and other pollutants in the air over the city.

FREEZE-FREE GROWING PERIOD

By definition, the freeze-free growing period is between the dates of the last 32°F temperature in spring and the first 32°F temperature in autumn, and is usually referred to as the growing season. (See maps 15, 16, and 17). Temperatures, however, may drop to freezing or below at the ground surface because of radiation on clear, calm nights even when the official low temperature measured in the shelter 4 feet above the ground is as high as 10 Farenheit degrees above freezing. Furthermore, very sensitive plants will be damaged or killed by temperatures as high as 5° to 10°F above freezing. The growth rate of very hardy vegetation, such as winter cereals and many grasses, usually is only restricted by freezing temperatures; such vegetation remains dormant during persistent cold weather and starts to grow again when moderate warmth returns.

The effect of low temperatures on vegetation depends on the variety and condition of plants before the freeze, the severity and persistence of low temperatures, and protection such as that afforded by a blanket of snow or other covering. Winter wheat, for instance, is economical to grow in the Great Plains as far north as north-central South Dakota; it will freeze during many winters if planted farther north. However, winter wheat is grown successfully farther north in the sheltered snow-

Table 1.—Record highest temperatures by States

State	Temp. (°F)	Date	Station	Elevation (feet)
Ala.	112	Sept. 5, 1925	Centerville	345
Alaska	100	June 27, 1915	Fort Yukon	—
Ariz.	127	July 7, 1905*	Parker	345
Ark.	120	Aug. 10, 1936	Ozark	396
Calif.	134	July 10, 1913	Greenland Ranch	−178
Colo.	118	July 11, 1888	Bennett	—
Conn.	105	July 22, 1926	Waterbury	400
Del.	110	July 21, 1930	Millsboro	20
D.C.	106	July 20, 1930*	Washington	112
Fla.	109	June 29, 1931	Monticello	207
Ga.	112	July 24, 1952	Louisville	337
Hawaii	100	Apr. 27, 1931	Pahala	850
Idaho	118	July 28, 1934	Orofino	1,027
Ill.	117	July 14, 1954	E. St. Louis	410
Ind.	116	July 14, 1936	Collegeville	672
Iowa	118	July 20, 1934	Keokuk	614
Kans.	121	July 24, 1936*	Alton (near)	1,651
Ky.	114	July 28, 1930	Greensburg	581
La.	114	Aug. 10, 1936	Plain Dealing	268
Maine	105	July 10, 1911*	North Bridgton	450
Md.	109	July 10, 1936*	Cumberland & Frederick	623; 325
Mass.	106	July 4, 1911*	Lawrence	51
Mich.	112	July 13, 1936	Mio	963
Minn.	114	July 6, 1936*	Moorhead	904
Miss.	115	July 29, 1930	Holly Springs	600
Mo.	118	July 14, 1954*	Warsaw & Union	687; 560
Mont.	117	July 5, 1937	Medicine Lake	1,950
Nebr.	118	July 24, 1936*	Minden	2,169
Nev.	122	June 23, 1954*	Overton	1,240
N.H.	106	July 4, 1911	Nashua	125
N.J.	110	July 10, 1936	Runyon	18
N. Mex.	116	July 14, 1934*	Orogrande	4,171
N.Y.	108	July 22, 1926	Troy	35
N.C.	109	Sept. 7, 1954*	Weldon	81
N. Dak.	121	July 6, 1936	Steele	1,857
Ohio	113	July 21, 1934*	Gallipolis (near)	673
Okla.	120	July 26, 1943*	Tishomingo	670
Oreg.	119	Aug. 10, 1898*	Pendleton	1,074
Pa.	111	July 10, 1936*	Phoenixville	100
R.I.	102	July 30, 1949	Greenville	420
S.C.	111	June 28, 1954*	Camden	170
S. Dak.	120	July 5, 1936	Gannvalley	1,750
Tenn.	113	Aug. 9, 1930*	Perryville	377
Tex.	120	Aug. 12, 1936	Seymour	1,291
Utah	116	June 28, 1892	Saint George	2,880
Vt.	105	July 4, 1911	Vernon	310
Va.	110	July 15, 1954	Balcony Falls	725
Wash.	118	Aug. 5, 1961*	Ice Harbor Dam	475
W. Va.	112	July 10, 1936*	Martinsburg	435
Wis.	114	July 13, 1936	Wisconsin Dells	900
Wyo.	114	July 12, 1900	Basin	3,500
P.R.	103	Aug. 22, 1906	San Lorenzo	203

* Also on earlier dates at the same or other places in the state.

Table 2.—Record lowest temperatures by States

State	Temp. (°F)	Date	Station	Elevation (feet)
Ala.	−24	Jan. 31, 1966	Russellville	880
Alaska	−80	Jan. 23, 1971	Prospect Creek Camp	1,100
Ariz.	−40	Jan. 7, 1971	Hawley Lake	8,180
Ark.	−29	Feb. 13, 1905	Pond	1,250
Calif.	−45	Jan. 20, 1937	Boca	5,532
Colo.	−60	Feb. 1, 1951	Taylor Park	9,206
Conn.	−32	Feb. 16, 1943	Falls Village	585
Del.	−17	Jan. 17, 1893	Millsboro	20
D.C.	−15	Feb. 11, 1899	Washington	112
Fla.	−2	Feb. 13, 1899	Tallahassee	193
Ga.	−17	Jan. 27, 1940	CCC Camp F-16	—
Hawaii	14	Jan. 2, 1961	Haleakala, Maui Island	9,750
Idaho	−60	Jan. 18, 1943	Island Park Dam	6,285
Ill.	−35	Jan. 22, 1930	Mount Carroll	817
Ind.	−35	Feb. 2, 1951	Greensburg	954
Iowa	−47	Jan. 12, 1912	Washta	1,157
Kans.	−40	Feb. 13, 1905	Lebanon	1,812
Ky.	−34	Jan. 28, 1963	Cynthiana	684
La.	−16	Feb. 13, 1899	Minden	194
Maine	−48	Jan. 19, 1925	Van Buren	510
Md.	−40	Jan. 13, 1912	Oakland	2,461
Mass.	−34	Jan. 18, 1957	Birch Hill Dam	840
Mich.	−51	Feb. 9, 1934	Vanderbilt	785
Minn.	−59	Feb. 16, 1903*	Pokegama Dam	1,280
Miss.	−19	Jan. 30, 1966	Corinth 4 SW	420
Mo.	−40	Feb. 13, 1905	Warsaw	700
Mont.	−70	Jan. 20, 1954	Rogers Pass	5,470
Nebr.	−47	Feb. 12, 1899	Camp Clarke	3,700
Nev.	−50	Jan. 8, 1937	San Jacinto	5,200
N.H.	−46	Jan. 28, 1925	Pittsburg	1,575
N.J.	−34	Jan. 5, 1904	River Vale	70
N. Mex.	−50	Feb. 1, 1951	Gavilan	7,350
N.Y.	−52	Feb. 9, 1934	Stillwater Reservoir	1,670
N.C.	−29	Jan. 30, 1966	Mt. Mitchell	6,525
N. Dak.	−60	Feb. 15, 1936	Parshall	1,929
Ohio	−39	Feb. 10, 1899	Milligan	800
Okla.	−27	Jan. 18, 1930*	Watts	958
Oreg.	−54	Feb. 10, 1933*	Seneca	4,700
Pa.	−42	Jan. 5, 1904	Smethport	—
R.I.	−23	Jan. 11, 1942	Kingston	100
S.C.	−13	Jan. 26, 1940	Longcreek (near)	1,631
S. Dak.	−58	Feb. 17, 1936	McIntosh	2,277
Tenn.	−32	Dec. 30, 1917	Mountain City	2,471
Tex.	−23	Feb. 8, 1933*	Seminole	3,275
Utah	−50	Jan. 5, 1913*	Strawberry Tunnel	7,650
Vt.	−50	Dec. 30, 1933	Bloomfield	915
Va.	−29	Feb. 10, 1899	Monterey	—
Wash.	−48	Dec. 30, 1968	Mazama & Winthrop	2,120; 1,755
W. Va.	−37	Dec. 30, 1917	Lewisburg	2,200
Wis.	−54	Jan. 24, 1922	Danbury	908
Wyo.	−63	Feb. 9, 1933	Moran	6,700
P.R.	40	Mar. 9, 1911	Aibonito	2,059

* Also on earlier dates at the same or other places in the state.

Table 3.—Highest temperatures in conterminous United States by month

Month	Temp. (°F)	Year	Day	State	Place	Elevation (feet)
Jan.	98	1936	17	Texas	Laredo	421
Feb.*	105	1963	3	Ariz.	Montezuma	735
Mar.*	108	1954	31	Texas	Rio Grande City	168
Apr.	118	1898	25	Calif.	Volcano Springs	−220
May*	124	1896	27	Calif.	Salton	−263
June*†	127	1896	15	Ariz.	Ft. Mohave	555
July	134	1913	10	Calif.	Greenland Ranch	−178
Aug.†	127	1933	12	Calif.	Greenland Ranch	−178
Sept.	126	1950	2	Calif.	Mecca	−175
Oct.*	116	1917	5	Ariz.	Sentinel	685
Nov.*	105	1906	12	Calif.	Croftonville	1,759
Dec.	100	1938	8	Calif.	La Mesa	538

* Two or more occurrences, most recent given.

† Slightly higher temperatures in old records are not used because of lack of information on exposure of instruments.

Table 4.—Lowest temperatures in conterminous United States by month

Month	Temp. (°F)	Year	Day	State	Place	Elevation (feet)
Jan.†	−70	1954	20	Mont.	Rogers Pass	5,470
Feb.	−66	1933	9	Mont.	Riverside R. S.	6,700
Mar.	−50	1906	17	Wyo.	Snake River	6,862
Apr.	−36	1945	5	N. Mex.	Eagle Nest	8,250
May	−15	1964	7	Calif.	White Mountain 2	12,470
June	2	1907	13	Calif.	Tamarack	8,000
July*	10	1911	21	Wyo.	Painter	6,800
Aug.*	5	1910	25	Mont.	Bowen	6,080
Sept.*	−9	1926	24	Mont.	Riverside R. S.	6,700
Oct.	−33	1917	29	Wyo.	Soda Butte	6,600
Nov.	−53	1959	16	Mont.	Lincoln 14 NE	5,130
Dec.*	−59	1924	19	Mont.	Riverside R. S.	6,700

† −80°F, Jan. 23, 1971 at Prospect Creek Camp, Alaska, elevation 1,100 ft.

* Two or more occurrences, most recent given.

covered valleys of western Montana. A growing season of at least 180 to 190 days is needed for the growth of cotton, 120 to 130 days for grain corn, and 90 days to 100 days for spring wheat. The long hours of summer daylight in northern areas compensate in large measure for the short growing season.

Many other temperature factors determine or limit the location and type of crops and natural vegetation. One such factor is the occasional occurrence of a hard freeze, usually early in autumn or unseasonably late in spring. Apples, peaches, cherries, and grapes are grown extensively along the Great Lakes, mainly on the leeward (eastern and southeastern) side because of the moderating effects of the lake waters on air masses passing over them. This moderating effect retards the premature development of fruits in spring and checks the occurrence of late frosts in spring and early frosts in autumn. On a larger scale the moderating effect of the Pacific Ocean helps make the Pacific States one of the greatest fruit and vegetable regions of the world.

The mean length of the freeze-free period in the conterminous United States is over 300 days in the lower Rio Grande Valley of Texas, along the gulf coast, and in most of Florida. The length of the growing season gradually decreases northward over the eastern two-thirds of the country to less than 120 days in the northern portions of Montana, North Dakota, Minnesota, and mountainous sections of New York, northern Pennsylvania, and northern New England. Freezes do not occur in the Florida Keys.

The freeze-free period in the Rocky, Cascade, and Sierra Nevada Mountains and the intermountain complex of the western States ranges from less than 30 days on the high mountains to from about 120 to more than 150 days in the more favored valley areas. There are over 300 growing days in the extreme southwest corner of Arizona and the adjacent corner of California. Along the Pacific coast the growing season exceeds 300 days in many areas, particularly on the extreme southern California coast where several years may pass without a freeze. The season ranges from 150 to more than 180 days in the Puget Sound area, the Willamette and lower Columbia Valleys, and is over 250 days in the Central Valley of California.

In Alaska, the freeze-free period ranges from 150 to more than 180 days in southern coastal areas to slightly over 90 days in the Matanuska, Tanana, and Yukon Valleys, and most of the west-central area. However, freezes occur every month and, in many cases every night, in the more northern areas and on the numerous mountains and glaciers.

Freezes do not occur in Hawaii, except above the 4,000 ft. level, and have never been reported in Puerto Rico or the Virgin Islands.

COLD SPELLS

The conterminous United States is subject to cold spells usually a few days in duration. Occasionally they intensify and persist over large areas for a few weeks and even months. During the persistent cold spell of 1936 over the northern Great Plains, the temperature at Amenia, N. Dak., did not rise above 0°F, except momentarily on January 30 to 1°F., for 47 consecutive days, January 3 until February 19. Cold arctic and polar air masses from Canada and the north Pacific Ocean, usually attended by snowfall along their leading edge, spread southward and eastward every few days during the winter over much of the conterminous United States. However, nearly every year a few severely cold air masses plunge deep into southern areas.

During 1816, called "The Year Without a Summer" in the Northeast, record-breaking cold spells occurred over much of New England. One, from June 6 to 11, brought snow squalls and scattered frost to the area; a second, from July 6 to 9, brought a few reported occurrences of frost. Much of the corn in the Northeast did not ripen that year.

One of the most severe and extensive cold waves on record overspread the eastern two-thirds of the conterminous United States from February 9 to 13, 1899, bringing record low temperatures to many areas. Some of these lows were: −15°F at Washington, D.C., on the 11th; −8°F at Ft. Worth, Tex., on the 12th; and −9°F at Atlanta, Ga., −2° at Tallahassee, Fla., −1°F at Mobile, Ala., 7°F at New Orleans, La., and 12°F at Brownsville, Tex., on the 13th. The Southeast had previously suffered a somewhat similar record-breaking disastrous freeze on February 8, 1835, when temperatures reportedly dropped to below 0°F in northeastern Florida.

During January 10 through 13, 1962, a severe cold wave overspread practically the entire eastern two-thirds of the conterminous United States, bringing temperatures as low as −8°F to El Paso, Tex. (an all time low), 19°F to Brownsville, Tex., 13°F to New Orleans, La., 7°F to Mobile, Ala., and 11°F to Tallahassee, Fla. Again in 1962, a cold wave on December 13 brought readings as low as −2°F to Fulton, Miss., 1°F to Atlanta, Ga., and 18°F to Tampa, Fla. The next month, January 1963, was among the coldest months of record for the conterminous United States, with a record low of −34°F in Kentucky and a near record low of −37°F in Arizona.

Florida usually experiences a few freezes in the northern and central sections each year. On a number of occasions, however, severe freezes have overspread practically the entire peninsula except the Keys, killing truck crops, freezing citrus on the trees, and killing and injuring many trees and shrubs. Most notable were those of February 8, 1835, and February 13, 1899. Cold waves on December 12 and 13, 1934, froze citrus on the trees, causing a loss of 10 million boxes; on January 27 through 29, 1940, the loss was 11 million boxes; and on December 12 and 13, 1957, over 22 million boxes.

In the lower Rio Grande Valley of Texas, the 1949 and 1951 freezes killed 75 percent of the 14 million citrus trees and the 1962 freeze destroyed 30 percent of the 7 million citrus trees. Freezes on January 8 to 11, 1937, and January 3 to 11, 1949, caused almost total loss of truck-farm vegetables and much damage to citrus, avocados, and shrubs in California––in the San Joaquin Valley and in the southern sections of the State, including the Imperial Valley and some southern coastal areas.

In the Pacific Northwest, the longest period of severe cold weather and the coldest of record for so early in the season overspread Washington and adjacent areas on November 11 to 16, 1955. This cold spell caused extensive damage to nursery stock, orchard trees, berry bushes, and shrubs, mainly because an unseasonably late warm autumn had made them highly susceptible to injury. Damage to crops in Washington alone exceeded $11 million.

HOT SPELLS

Unusually hot spells and persistent very warm periods are enervating and oppressive, are very demanding on water supplies, intensify drought conditions, and are the main cause of about 450 deaths in an average year. A few hot spells usually occur each summer in various sections of the country. References are frequently made to the hot summer of 1830 in the North Central Interior and to the heat and drought of the summer of 1860 in the Great Plains. July 1901 was one of the hottest months of record in the Great Plains; Lawrence, Kans., for instance, reported readings of 100°F or higher on 21 days and readings of 90° or higher on every day of that month.

The most outstanding periods of heat occurred in connection with the droughts and duststorms in the Great Plains during the summers of 1930, 1934, and 1936; each was progressively more severe. Temperature averages for the July through August periods of 1934 and 1936 ranged from 5 to more than 8 Farenheit degrees and from 6 to more than 10 Farenheit degrees above normal, respectively, in the central Great Plains and middle Mississippi Valley area. An example of the persistent heat was readings of 100°F or higher (with a record 113°F on August 14) on 53 days during the summer of 1936 at Kansas City, Mo. Record highs of 121°F occurred in North Dakota and Kansas, and 120°F in South Dakota, Oklahoma, Arkansas, and Texas. Alltime record State highs also were set or equalled in 10 other States in 1936—Indiana, Louisiana, Maryland, Michigan, Minnesota, Nebraska, New Jersey, Pennsylvania, West Virginia, and Wisconsin.

Many States had their hottest summer of record in 1952, with a record heat death total of 1,401. The summer of 1954 was also unusually hot, with 978 deaths attributed to heat.

A heat wave during July and August 1955 brought persistent, much above normal summer warmth from the middle Great Plains area to the Atlantic coast, but it did not bring drought conditions or record temperatures. Nevertheless, the heat and humidity were very oppressive, especially in cities; many stations recorded record numbers of days with temperatures of 90°F or above. During this summer and each following summer though 1961, the Far Southwest suffered from unusually warm summers. The heat was particularly oppressive in 1959, when June, July, August, and September were each the warmest of record at Los Angeles, Calif.; the same record heat occurred during June and July at Yuma, Ariz.

High humidity added to the discomfort of the 1966 heat wave that prevailed over the northern and middle Interior during most of July. This heat wave also affected the North and Middle Atlantic Coast during the first 2 weeks of the month. Afternoon temperatures exceeded 100°F on 24 days at Wichita Falls, Tex., on 6 days at Huron, S. Dak., on 8 days at Springfield, Ill., and on 5 days in many sections of the Northeast. The 107°F highs of July 3 at Harrisburg, Pa., and New York, N.Y. were alltime records. The heat was blamed for several hundred deaths; about 70 occurred in the St. Louis, Mo., area, where readings exceeded 100°F on 6 consecutive days (July 9–14, 1966).

HEATING DEGREE DAYS

One of the most practical of weather statistics is the "heating degree day." First devis[illegible]ome 50 years ago, the degree-day system has been in quite general use by the heating industry for more than 30 years.

Heating degree days are the number of degrees the average temperature for the day is below 65°F. For example, a day with an average temperature of 50°F has 15 heating degree days (65 − 50 = 15), while a day with an average temperature of 65°F or higher has no heating degree days. Normally, heating is not required in a building when the outdoor average daily temperature is 65°F. The amount of heat required at lower temperatures is proportional to the degree-day value. A fuel bill usually would be about twice as high for a month with 1,000 heating degree days as for a month with 500 heating degree days. Comparing normal seasonal degree days in different locations gives a rough estimate of seasonal fuel consumption. For example, it would require roughly four and one-half times as much fuel to heat a building in Chicago, Ill., where there is a mean annual total of about 6,200 heating degree days, as would to heat a similar building in New Orleans, La., where the annual heating degree days total is about 1,400. Using degree days has the advantage that the consumption ratios are fairly constant, i.e., the fuel consumed per 100 degree days is about the same whether the 100 degree days occur in only 3 or 4 days or are spread over 7 or 8 days. Heating degree day values are used for scheduling fuel deliveries and for evaluating use rates and peak demands.

The mean annual heating degree days total about 100 in the Florida Keys, and less than 1,000 in the Florida Peninsula and extreme southern Texas (map 18). Mean annual heating degree days increase to 5,000 across most of the middle of the eastern two-thirds of the country, reach over 9,000 in northern New England, and over 10,000 near the Canadian border from the Rockies to the Great Lakes, and in the high Rockies. There usually are less than 2,000 heating degree days a year in southeastern California, southwestern Arizona, and along the extreme southern California coast.

In Alaska mean annual heating degree day totals range from near 10,000 in the southern and southwestern coastal areas and islands, to over 20,000 in the extreme northern portion. Heating degrees days do not occur in Hawaii, except high in the mountains, nor in Puerto Rico and the Virgin Islands.

COOLING DEGREE DAYS

In contrast to heating degree days, cooling degree days, as used by the National Oceanic and Atmospheric Administration, are the number of degrees the average temperature for the day is above 65°F. For example, a day with an average temperature of 80°F has 15 cooling degree days (80 − 65 = 15), while one with an average temperature of 65°F or lower has no cooling degree days.

Mean annual cooling degree days in the conterminous United States (map 19) total over 3,000 in extreme southeastern California, southwestern Arizona, southern Texas, and central and southern Florida, decreasing to 1,500 east of the Rockies as far north as a line from central Kansas through northern Kentucky and to southern Virginia, and to 500 in central North Dakota, Lower Michigan, and Connecticut. Cooling degree days are negligible on the north Pacific coast, at high elevations of the Cascades, the Sierra Nevada, and the Rockies, and in Alaska.

EFFECTIVE TEMPERATURE

Effective Temperature is an index of the degree of warmth experienced by the body on exposure to different combinations of temperature, humidity, and air movement. This measurement was developed in a series of studies in 1923 at the Research Laboratory of the American Society of Heating and Air Conditioning Engineers. Figure 2, showing the relation of effective temperature to comfort is adapted from the Society's annual publication "Heating Ventilating Air Conditioning Guide."

The Temperature-Humidity Index is a measurement developed in 1958 as a modification of the Effective Temperature method. The Temperature-Humidity Index (THI), originally called the Discomfort Index, can be computed from one of the following equations:

$$\mathrm{THI} = 0.4\,(t_d + t_w) + 15$$
$$\mathrm{THI} = 0.55t_d + 0.2t_{dp} + 17.5$$
$$\mathrm{THI} = t_d - [(0.55 - 0.55\mathrm{RH})(t_d - 58)]$$

where

t_d = dry bulb temperature
t_w = wet bulb temperature
t_{dp} = dewpoint temperature
RH = relative humidity

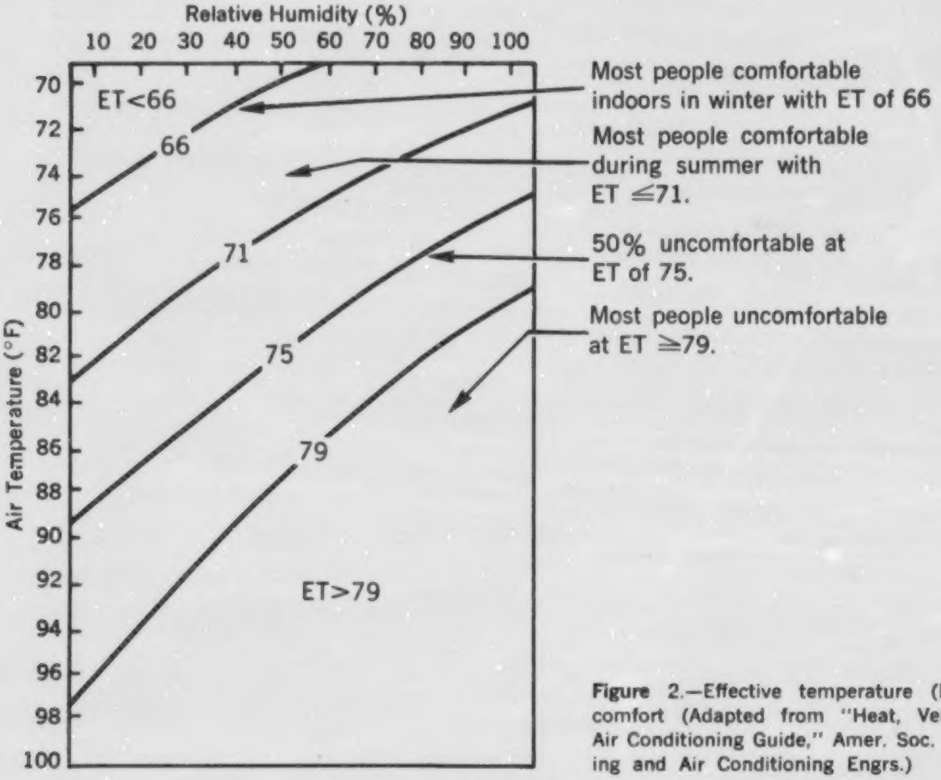

Figure 2.—Effective temperature (ET) and comfort (Adapted from "Heat, Ventilating, Air Conditioning Guide," Amer. Soc. of Heating and Air Conditioning Engrs.)

Wind speed (mi/h)	Dry bulb temperature (°F)																		
	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45
4	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45
5	43	37	32	27	22	16	11	6	0	−5	−10	−15	−21	−26	−31	−36	−42	−47	−52
10	34	26	22	16	10	3	−3	−9	−15	−22	−27	−34	−40	−46	−52	−58	−64	−71	−77
15	29	23	16	9	2	−5	−11	−18	−25	−31	−38	−45	−51	−58	−65	−72	−78	−85	−92
20	26	19	12	4	−3	−10	−17	−24	−31	−39	−46	−53	−60	−67	−74	−81	−88	−95	−103
25	23	16	8	1	−7	−15	−22	−29	−36	−44	−51	−59	−66	−74	−81	−88	−96	−103	−110
30	21	13	6	−2	−10	−18	−25	−33	−41	−49	−56	−64	−71	−79	−86	−93	−101	−109	−116
35	20	12	4	−4	−12	−20	−27	−35	−43	−52	−58	−67	−74	−82	−89	−97	−105	−113	−120
40	19	11	3	−5	−13	−21	−29	−37	−45	−53	−60	−69	−76	−84	−92	−100	−107	−115	−123
45	18	10	2	−6	−14	−22	−30	−38	−46	−54	−62	−70	−78	−85	−93	−102	−109	−117	−125

Figure 3.—Wind chill equivalent temperature

All "*t*" values are in degrees F, and the "*t*" values and the RH in each equation are simultaneous readings. The relative humidity is used in its decimal form (i.e., 0.65 instead of 65%).

A temperature-humidity index of 60 is generally used as a base for comparison. In summer, relatively few people will be uncomfortable because of heat and humidity while the index is 70 or below, about half of the population will be uncomfortable when the index reaches 75, and almost everyone will be uncomfortable when it reaches 80.

WIND CHILL

The effect of a given temperature on the human body is greatly modified by wind and humidity conditions. The effects of humidity were shown in the section on Effective Temperature. The effect of wind is to lower body temperature by evaporating perspiration or merely by advecting (blowing) heat away from the surface of the skin. Figure 3 shows the temperature you feel on your skin under given conditions of temperature and wind. Note that the chilling effect increases as the wind speed increases. When winds exceed 40 miles per hour, there is little additional chilling effect.

Chapter 4

Precipitation

All precipitation—rain, drizzle, snow, hail, ice pellets, glaze ice—is recorded. Precipitation is measured either directly in inches of water or indirectly by converting other measurements, such as snow depth, to their water equivalents. For example, an accumulation of dry, moderate-sized snow flakes 10 inches in depth is roughly equivalent to 1 inch of water. Measurements of the depth of snow on the ground are made and recorded regularly. At the same time, a snow sample, either the snow accumulated in a rain gage, or a sample taken according to strict specifications, is melted and the resulting water is measured and recorded as inches of precipitation. Some precipitation gages are designed to catch and melt snow and other frozen precipitation as it falls; direct measurements of water equivalent are made with these gages.

In this chapter, the climatic precipitation and snow conditions of the United States are described in detail. Record rains and snowfalls are also listed.

DISTRIBUTION OF PRECIPITATION BY AREA

Conterminous United States

On the United States mainland, exclusive of Alaska, the heaviest annual precipitation falls in the mountains of western Washington (Map 20). Here normal total precipitation is as great as 144 inches per year in the Olympic mountains, and 115 inches in the Cascade Range. Average annual totals in the coastal regions of Washington and Oregon, and in the Cascade Range of Oregon range from 80 inches to more than 100 inches. Over northwestern California and in the Sierra Nevada, totals average 50 to 60 inches per year.

The Intermountain Plateau or Great Basin region that lies to the east and south of this heavy rain area is the driest part of the country. Annual precipitation totals in this region average 8 to 15 inches. Locally, the annual totals are over 20 inches on small mountain ridges, and less than 4 inches in the deserts of Arizona and southern California. Farther west, in the Sacramento-San Joaquin valley area, annual totals range from 8 to 16 inches a year.

The northern and central sections of the Rocky Mountain region receive from 20 to more than 40 inches of precipitation per year; the extreme southern part of this area receives less than 20 inches a year.

In the eastern foothills of the Rockies precipitation amounts are rather small; the average annual totals are 12 to 16 inches. East of the foothills precipitation increases, reaching 30 inches per year over central Kansas, Iowa, and the Great Lakes, over 50 inches in Tennessee and the central and eastern Gulf States, and from 45 to over 50 inches in the Appalachians and the Atlantic coastal areas. Over 60 inches of precipitation fall in the central gulf coast area, extreme southeastern Florida, and the southern Appalachians. Extreme eastern Tennessee and western North Carolina have local annual precipitation totals of 80 or more inches.

The conterminous United States as a whole has a mean annual precipitation total of 29 inches. This total is based on a 77-year record.

Alaska

The southeastern and central south coast and island areas of Alaska have an average of over 100 inches of precipitation annually; locally in this region totals reach more than 150 inches per year. Precipitation totals decrease somewhat over the Aleutians. Inland from the south coast, precipitation totals decrease rapidly, with annual totals of 16 inches in the Anchorage area, 12 inches at Fairbanks and central Yukon basin, 16 inches at Nome, and 4 inches at Point Borrow.

Hawaii

Rainfall distribution in Hawaii is most strongly influenced by the northeast trade winds and the topography. On the northeast and east (windward) slopes of the mountains, up to the 5000-foot level, total precipitation ranges as high as 400 inches per year. On the lee side of the mountains, and at elevations above 6000 feet, rainfall ranges from less than 10 inches to a little more than 30 inches per year.

Puerto Rico and Virgin Islands

Rainfall along the north, east, and west coasts of Puerto Rico averages 60 to 65 inches a year. Inland, along the east-west mountain ridges, annual precipitation totals range from 80 to more than 100 inches. To the lee of the mountains, along the central and western parts of the south coast, annual precipitation averages less than 40 inches. Annual rainfall in the Virgin Islands ranges from about 35 inches in sheltered areas to about 50 inches in hilly sections.

PRECIPITATION EXTREMES

Extremes of any weather element are the highest and lowest values on record for that element for a given time period. Strictly speaking, the highest or lowest value for an entire record (for example, the entire 77 years of record at Station X) is called the absolute extreme.

The greatest mean annual precipitation on record for the entire world is 460 inches at Mt. Waialeale, on the island of Kauai, Hawaii. Other greatest mean annual amounts of precipitation in the United States are:

Amount in inches	Location
144.43	Wynoochee Oxbow, Wash. (conterminous U.S.)
221	Little Port Walter, Alaska
112.63	Guineo Reservoir, Puerto Rico

Records for a single calendar year are:

Amount in inches	Location
578	Puu Kukui, Maui, Hawaii (1950)
269.30	Little Port Walter, Alaska (1943)
184.56	Wynoochee Oxbow, Washington (1931)

At Cherrapunji, India, where the mean annual rainfall is about 450 inches, a record of 1,041.78 inches of rain fell during the 12 months from August 1960 through July 1961. Cherrapunji also recorded 150 inches of rain in five days during a monsoon. The world record for a 5-day rainfall, 151.73 inches, occured at Cilaos on the island of La Reunion in the south Indian Ocean (March 13–18, 1952).

Other record rainfalls are:

Inches	Period & dates	Location	Record
107	March 1942 (month)	Puu Kukui, Maui	U.S.
71.54	January 1909 (month)	Helen Mine, Calif.	U.S.
38.70	24 hrs—Sept. 5–6, 1950 (hurricane)	Yankeetown, Fla.	U.S.
73.62	24 hrs—March 15–16, 1952	Cilaos, La Reunion	World
12.00	1 hr—June 22, 1947 Jan 24–25, 1956	Holt. Mo. Kilauea Sugar Plantation, Kauai, Hawaii	U.S.
1.23	1 minute—July 4, 1956	Unionvilie, Md.	World

At the other extreme, the least mean annual rainfall in the United States is 1.78 inches for Death Valley, California. The world record for least mean annual rainfall is held by Arica, Chile (0.03 inch). Bagdad, California, holds the United States record for the longest period without measurable precipitation: August 18, 1909, through May 6, 1912, a period of 993 days. Greenland Ranch, Death Valley, California had no precipitation from December 4, 1928 through January 6, 1930 (399 days). In other parts of the world more extreme records for low precipitation are in existence; the deserts of Africa, Arabia, central Asia, and northern Chile sometimes go without a drop of rain for several years. Iquique, Chile, went without measurable rain for 14 years.

PRECIPITATION DAYS PER YEAR

Conterminous United States

Measurable precipitation—0.01 inches or more—occurs on an average of over 100 days per year in the eastern half of the conterminous United States, in the mountainous areas of Colorado, Wyoming, Montana, and Idaho, and in coastal and the Cascade Range areas of Washington and Oregon (map 21). Precipitation occurs on 150 or more days a year in the following areas: northern Michigan, the Appalachians from Ohio to Maine, a few small areas of the central and northern Rockies, and the area from the Washington and Oregon coasts to the Cascade Range. Precipitation days are in excess of 200 days per year in some localities in the Olympic and Cascade Ranges of Washington. Extreme southeastern California, western Arizona, and extreme southern Nevada report from less than 20 to about 30 precipitation days annually.

Alaska

In Alaska, more than 200 days with precipitation occur annually at locations on the islands along the south coast and on the south coast itself, and 250 days per year at locations on the southeast coast. The number of days with precipitation decreases inland to 100 to 150 days annually over the southwest and south and to 70 to 100 days over the northern half of the State.

Hawaii

Rain occurs on 250 to 300 days a year on the windward (east) slopes of the mountains at elevations between 2,000 to 5,000 feet. On the lee sides of the islands and at elevations above 6,000 feet there are from 20 to 100 rainy days per year.

Puerto Rico and Virgin Islands

On Puerto Rico rain falls on 170 to 200 days annually along the northeast and east coasts, 250 to 300 days a year in the interior mountain areas, and 100 days or less along the central part of the south coast. Rain falls in the Virgin Islands about 100 days per year in most lee side areas, and about 200 days per year in hilly sections.

SEASONAL DISTRIBUTION OF PRECIPITATION

The normal seasonal distribution of precipitation varies from place to place over the **United States.**

In the Pacific coastal region and the Cascade-Sierra Nevada areas more than four-fifths of the annual precipitation occurs during winter. In the northern sections of the region, precipitation occurs 16 to 20 days a month from November to March, decreasing to 4 to 10 days per month during July and August. California receives most of its precipitation during the cold months (December through March) with 8 to 12 rainy days per month. Summer precipitation in California is slight, with 1 to 4 days per month with measurable rainfall from July through September.

In the Intermountain Plateau region, where total precipitation is small, most of the precipitation falls in the north and north central sections during the colder part of the year. There are 8 to 16 precipitation days per month from November through March, and only 2 to 8 days per month from July to September in these sections. The southern sector has 4 to 8 rainy days per month from December to March and from less than 1 to 6 days per month during April through June and September through November. In July and August there are 8 to 12 rainy days per month in most of Arizona and New Mexico because of an occasional incursion of moist air from the Gulf of Mexico.

In the northern Rockies precipitation days per month range from 10 to 14 from November through June to 8 to 10 from July through October. Over the central Rockies there are 12 to 14 precipitation days per month except during the September through November period, when the number drops to 8 to 10 days per month. In the southern Rockies the average number of precipitation days per month is 8, rising to 12 to 14 during July and August.

More than three-fourths of the annual precipitation of the eastern foothills of the Rockies, the Great Plains, and the upper Mississippi River areas occurs during the warm half of the year. During this April to September period there is a definite peak of precipitation in the southern portions during May and in the northern portions during June. During the peak months there are 8 to 12 days with measurable precipitation in the Western Great Plains and 11 to 13 days in the upper Mississippi Valley. During the winter months the range for the area is 4 to 9 days per month.

Farther east, over the Great Lakes region, summer rainfall peaks become less pronounced, and the number of days with precipitation are more frequent in winter than in summer, particularly in the central and eastern lakes region. The number of precipitation days per month at Buffalo, N.Y., ranges from 9 in August to 19 in January. The eastern shores of the Great Lakes experience more frequent precipitation in winter than the west shores. This occurs because the prevailing westerly winds pick up heat and moisture as they pass over the lakes. When this warm moist air comes onshore on the eastern end of the lake, clouds form and drop precipitation in the form of snow.

In the northeastern United States, the total monthly precipitation is more evenly distributed throughout the year than elsewhere in the counry. Precipitation occurrence over this region, however, ranges from 9 to 14 days per month in September and October to 12 to 18 days per month from November through May.

Most of the precipitation on the south Atlantic coastal plains, and to a somewhat lesser extent in the middle Atlantic coastal area, occurs during the summer and early autumn months. Much of this precipitation comes from thunderstorm and tropical storm activity. Florida receives about two-thirds of its normal annual rainfall during the 5-month period of June through October. During these months rain falls on 13 to 18 days a month; but during November through April, rainy days in the area average 5 to 8 days per month. Across the southern tier of states, from Arkansas and northern Louisiana eastward into Georgia, the amount and frequency of precipitation from August through October is somewhat less than during the other months of the year.

The heaviest precipitation areas of **Alaska** are the southeastern and south-central coasts and their outlying islands. The greatest amounts of precipitation fall in these areas during October through December with 20 to 25 precipitation days per month; during the remainder of the year, there are 16 to 20 precipitation days per month. Most of the precipitation across the central and northern sections of Alaska falls during July through September; there are 10 to 15 precipitation days per month at Anchorage and Fairbanks, 11 to 18 at Nome, and 8 to 10 at Point Barrow.

In **Hawaii**, precipitation frequency and amounts are rather evenly distributed throughout the year on the windward slopes of the mountains; here at the 2000-

to 5000-foot levels, rain occurs on 20 to 29 days per month. On the west coast of the island of Hawaii, summers are wetter than winters. For the rest of the islands at elevations below 2,000 feet and above 6,000 feet, the season of highest average rainfall is the October through April cool period. Some of the dry lee side areas of the islands have measurable rain only 1 to 10 days a month.

Rainfall in **Puerto Rico** is heaviest from May through November with peak falls in May and September. The dry season runs from about December to April in the south and from February to April in the north. Rainy days along the northeast and east coasts range from 12 to 15 a month from February through April, and from 15 to 22 a month in July and August. On the north central and northwest coasts, rain falls on an average of 8 to 10 days a month from February through April and 12 to 15 during November and December. On the central south coast, which is sheltered from the northeast trade winds, rain falls on an average of 3 to 7 days per month from December through August and on 8 to 10 days per month from September through November. The number of rain days per month increases inland from the coast, reaching an average of 20 to 30 days per month on the high ridges.

The **Virgin Islands** have a dry season from January through April and a wet season from August through November. Rainfall days per month range from 7 to 11 in March (with 1 to 2 inches of rainfall) and increase to 13 to 18 from September through November (with 5 to 8 inches).

SNOWFALL

The mean annual snowfall in the United States ranges from none at all in southern Florida, parts of Arizona and southern California, Puerto Rico, and the Virgin Islands to a record mean of 575 inches at Paradise Ranger Station on Mount Rainier in the state of Washington. (See maps 25, 26, and 27).

Mean annual snowfall at the higher elevations in the western mountains ranges from 100 to over 200 inches per year. Snowfall exceeds 500 inches per year at some locations in the Cascade Range in Washington. In upper Michigan, northern and western New York, and New England, annual snowfall averages over 100 inches. Totals tend to be smaller at lower elevations and in the southern sections of the United States. A general characteristic of snowfall is that it is very erratic, especially in the warmer sections of the country where a single storm may bring as much or more snow in a day or two than the total for the area over a period of many years.

The mean annual snowfall in the Gulf Coast areas is less than 1 inch. The southern half of Georgia and South Carolina, the southern quarter of Texas, southwestern Arizona, and the deserts, central valleys, and coastal areas of California also have mean annual snowfall totals of less than 1 inch. Measurable amounts of snow fall at the Gulf Coast about once in ten years. A memorable snowfall on the Gulf Coast occurred over a 24-hour period on February 14 and 15, 1895, when 15.4 inches fell at Galveston, Texas, 24.0 inches at Rayne, La., and 8.2 inches at New Orleans, La. Another record was set at New Orleans when 4.5 inches of snow fell on December 31, 1963. Northern Florida was covered with from 1 to more than 3 inches of snow in 1899 and 1958, on February 13 of both years. The state record for Florida was set with 4 inches of snow on the ground at Lake Butler, February 13, 1899. An unofficial report of 5 inches along the St. Marys River was made on the morning of January 11, 1800. No measurable snow has ever been reported in southern Florida, Yuma, Ariz., or San Diego, Calif.

Paradise Ranger Station in Mount Rainier Park, Wash., which has the greatest mean seasonal snowfall (575 in) in the conterminous United States, had a record total of 85 feet 7 inches (1,027 in) during the 1970–71 season. The greatest one month record was set in January 1911 at Tamarack, California, where 390 inches of snow fell. The short period record snowfall was at Silver Lake, Colo., where a total of 87 inches fell in 27½ hours on April 14 and 15, 1921; this included the 24-hour U.S. record of 75.8 inches. The greatest amount ever recorded for one storm was 189.0 inches at Mt. Shasta Ski Bowl, Calif.; this fall occurred on February 13 through 19, 1959. The greatest depth of accumulated snow on the ground was 451 inches, measured at Tamarack, California on March 11, 1911.

Mean annual snowfall in Alaska ranges from about 30 inches on the Arctic coast, 60 inches in the Yukon Valley, to 100 to over 200 inches in the southeast areas. The greatest mean seasonal snowfall in Alaska falls at Thompson Pass; here the mean is 600 inches. Thompson Pass also holds the State seasonal record of 974.4 inches (1952–1953) and the 24-hour record of 62.0 inches (December 29, 1955).

As much as 12 to 24 inches of snow falls on mountain tops in Hawaii; there is no snowfall here at elevations below 5,000 feet.

ANNUAL SNOW DAYS

Only days on which 1 or more inches of snowfall are counted as snow days (map 28). The number of snow days over the northern states east of the Rockies exceeds 10 per year. There are 20 to more than 30 snow days per year in the upper Great Lakes region and northwestern Lower Michigan, in the area from eastern West Virginia and the extreme western parts of Virginia and Maryland to western Pennsylvania, and in most of New York and New England. Over 40 days of snow occur annually in locations on the east shore of Lake Ontario and in extreme northern New Hampshire. Days with measurable snow decrease southward to less than 1 day a year over the southern parts of Louisiana, Mississippi, and Alabama, and central and southern parts of Georgia and South Carolina, and northern Florida. Southern Florida peninsula never has snow.

There is less than 1 day of snow per year in California's Central Valley and southeastern deserts, and in western Arizona. There are no snow days on the south coast of California or in the vicinity of Yuma, Arizona. The annual number of snow days in the Far West increases northward to more than 40 days in the mountains of Colorado, Wyoming, Idaho, western Montana, Utah, California, Oregon, and Washington. There are over 80 snow days a year in the Cascade Range of Washington.

Snow days in Alaska range from 8 to 15 per year in the north, 11 to 30 across the central portions of the State, 14 to 20 over the Aleutian Islands, and over 50 days in the Yakutat-Thompson Pass area.

SNOW COVER

Snow covers the ground an average of more than 120 days a year in North Dakota, northern Minnesota, the upper Great Lakes region, the northern parts of New York and New England, and the northern and central ridges of mountains of the Far West. Locally, the higher elevations of the central and northern Rockies and the Cascade Range in Washington and Oregon are covered with snow all year; small glaciers are found in such locations. The number of days with snow cover on the ground decreases at locations farther south. The minimum number of snow cover days occurs on the southern part of the Pacific Coast, the valleys of central and southern California and southwestern Arizona, the lower valley of the Rio Grande of Texas, the Gulf Coast, extreme southern Georgia, and northern Florida. In these areas snow is found on the ground for a single day once every few years. In such areas snow usually melts as it strikes the ground; at most it remains on the ground from a few hours to a day or two. No snow cover has been reported for southern Florida, the extreme southern part of the California coast, or Yuma, Arizona.

High areas of Alaska are snow covered year round. There are many glaciers in the mountains, particularly in the Alaska Range to the north and east of Anchorage.

Occasionally there is snow cover on mountain tops in Hawaii between the beginning of December and the end of February. Neither Puerto Rico nor the Virgin Islands ever experience snow.

Chapter 5

Snowstorms, Blizzards, and Ice Storms

SEVERE SNOWSTORMS

Several severe snowstorms occur nearly every year in the northern and central sections of the country and occasionally as far south as the Gulf of Mexico. These winter storms cripple transportation, close schools, and cause widespread disruption of normal activities. Many assume the proportions of blizzards. Noteworthy among these were the following:

Storm date	*Area affected*
March 11–14, 1888	East
Feb. 11–14, 1899	Middle and North Atlantic States
Jan. 11–12, 1918	Midwest
Jan. 1–6, 1949	Great Basin, mid-Rockies, Northwest Plains

These are discussed briefly in the BLIZZARDS section of this chapter.

During the 34 years ending in 1970, over 3,300 deaths attributable to the effects of snowstorms and blizzards were reported. About one-third resulted from traffic or other accidents, one-fourth from overexertion, exhaustion, or fatal heart attacks—many from shoveling snow. Other major causes of death were exposure, freezing, house fires, carbon-monoxide poisoning in stalled cars, falls on slippery walks, electrocution from downed wires, and collapse of buildings. About one-half of the deaths occurred in the heavily populated areas of Pennsylvania, New York, and New England.

SOME OUTSTANDING SNOWSTORMS

1717 February 19–24, New England

The "great snow" remained 5- to 6-ft deep on level areas over all settled parts of New England. Livestock and other animals smothered or starved to death. Drifts covered many one-story houses.

1798 November 17–21, New England

One of most severe storms ever known in area. Heavy snow, accompanied by high winds. Great damage to vessels and much loss of life along coast. Many houses buried so deeply in snow, tunnels were necessary to get out.

1800 January 10, Georgia-Florida (North)

Snowfall to 18 in. in Savannah-Midway area, Ga., and to 5 in. (unofficial) along St. Mary's River, Fla.

1846 Early Winter, California

Wagon train of pioneers trapped by heavy snowfall near Donner Lake waited 4 months for rescue. Of 81 in party, only 45 survived.

1895 February 14–15, Louisiana-Mississippi

Very cold with snowfall from a few inches at Mississippi jetties to 2 ft in southwestern Louisiana; heaviest fall in years at many stations in Mississippi and eastern Texas. At Rayne, La., 24 in. in 24 hours, for storm, greatest to that date in State. Galveston, Tex., reported 15.4 in. in 24 hours.

1921 April 14–15, Colorado

Snowfall at Silver Lake 75.8 in. in 24 hours, greatest 24-hour amount in Nation; 87 in. fell in 27½ hours and 95 in. in 32½ hours. At Fry's Ranch, 62 in. fell in 22 hours. Snow drifted to depths of 7 ft in many parts of Denver and to 8 ft near Corona. Many trees broken and telephone and telegraph poles splintered.

1922 January 27–29, Atlantic Coastal States

Great snowstorm deposited from 1½ to over 3 ft of snow from South Carolina to southeastern Massachusetts; 36 in. at Roxboro, N.C.; 28 in. in the District of Columbia; 26.5 in. at Baltimore; 19.1 in. at Richmond, Va.; and 18 in. at Wilmington, Del. A few dozen buildings and

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NOTE: Dollar figures cited on damage are estimates made at time of occurrence; comparisons are impractical because of changes in the value of the dollar.

warehouses collapsed. In District of Columbia, the collapse of the Knickerbocker theater killed 98, injured 120. At Washington, D.C., a fall of 25 in. in 24 hours set single storm and 24-hour snowfall records.

1947 December 26–27, New York-New Jersey-New England

Snowfall 29.7 in. at Long Beach, N.J., for greatest 24-hr. fall of record in State. Snowfall averaged 25.8 in. in New York City with 4 deaths and damage in millions of dollars; snow removal cost over $4 million. New Jersey reported 23 deaths.

1952 January 11–16, California-Nevada-Idaho

In Nevada, 22 in. in 24 hours at University of Nevada Experiment Farm and storm total of 44 in. at Marlette Lake set records for State. In Idaho, 26 in. at Arco in 24 hours and 52 in. at Sun Valley for storm records in that State. At Tahoe, Calif., 149 in. fell for greatest of record in single storm in Nation, excepting Alaska (until 189 in. fell at Mt. Shasta Ski Bowl, Calif., Feb. 13–19, 1959). Two deaths in California.

1958 February 13–19, North Carolina-Virginia-Maryland-District of Columbia-Delaware-Pennsylvania-New Jersey

Snowfall 6 in. to over 3 ft; Baltimore 15.5 in.; Washington, D.C. 14 in. Transportation paralyzed. 24 deaths in Pennsylvania, 17 in North Carolina, and 2 in Virginia. Damage estimated at $500 million in Maryland, Delaware, and District of Columbia, and $20 million in North Carolina.

1958 March 19–22, Virginia-Maryland-Pennsylvania-New Jersey-New York-New England

Unusually late, heavy snowstorm. Called worst storm in 40 years in southeastern Pennsylvania. Snowfall 17.7 in. at Trenton, N.J., greatest since February 1899; 30 in. fell at Baltimore, Md.; 25 in. in Sussex County, N.J. Many roofs collapsed. Damage of $10 million in Maryland and in Pennsylvania and over $3½ million in New Jersey. 27 deaths in Pennsylvania, 9 in in New York, 8 in Maryland, 3 in Massachusetts, and 1 each in New Hampshire and Rhode Island.

1961 January 19–20, North Carolina-Virginia-District of Columbia-Maryland-Delaware-Pennsylvania-New Jersey-New York

Snowfall in Maryland 2 to 16 in.; Delaware to 11 in.; District of Columbia 8 to over 12 in.; Virginia to 12 in.; Pennsylvania 4 to 19 in.; New Jersey 10 to 30 in.; and New York 6 to 12 in. Heavy drifting in most of area. Great traffic jams in northern and central Virginia and the District of Columbia the day and night before inauguration of President John F. Kennedy. Communities and cities paralyzed in southern and eastern Pennsylvania. Cost of snow removal in milions of dollars. Deaths: 15 in North Carolina; 7 in New York; 5 in Maryland and the District of Columbia; 4 in Pennsylvania; 3 in New Jersey; 2 in Virginia; and 1 in Delaware—mostly due to overexertion and accidents.

1961 February 3–5, North Carolina-Virginia-District of Columbia-Maryland-Pennsylvania-New Jersey-New York-New England

Snowfall 2 to 13 in. in Virginia; 8 in. in the District of Columbia; 10 to 24 in. with 10-ft drifts in Pennsylvania; up to 27 in. with 4-ft drifts in New Jersey; 18 to 36 in. with severe drifting in central and southeastern New York State; and 7 to 25 in. with drifts 7 to 15 ft over much of southern New England. Blizzard intensity with severe cold and gale force winds. Transportation facilities paralyzed. Many roofs collapsed. State of emergency declared in some communities. 73 deaths reported—22 in New York, 19 in Massachusetts, 15 in Pennsylvania, 10 in Connecticut, 4 in Virginia, 2 in New Jersey, and 1 in Rhode Island. Damage in millions of dollars.

1963 December 31–January 1 (1964), Louisiana-Mississippi-Alabama-Tennessee

Snowfall from 2 in. Mobile; 4 in. New Orleans; 10½ in. Bay St. Louis, to over 16 in. northern sections of area, following freezing rain and sleet in many areas. Numerous new snowfall records set. Trees, power lines, and telephone lines damaged, and roofs collapsed by weight of wet snow and ice. Many roads closed. Damage over $1 million. Several deaths.

1967 December 12–20, Arizona (north, central, and east)-New Mexico (western two-thirds)-Colorado (southwest)-Utah (southeast).

Almost daily snowfall, low temperatures, and strong winds. Record to near record snowfall and severe drifting, many drifts 10 to 20 ft high, roads blocked, farms, ranches, livestock, and towns isolated. Snow vehicles and airlift used to bring food to families and feed to livestock. Suffering severe, especially on Indian reservations. Many buildings crushed by weight of snow. Record depth of 83 in. on ground at Flagstaff, Ariz. At least 11 deaths.

1969 February 9–10 and 23–28, New England

In first storm, snowfall of 1 to 3 ft blown into drifts up to 15 ft by gale-force winds. Second storm worst since 1869 in some areas, and since February 1717 (Whittier's "Snowbound") in a few others. Snowfall 1 to 4 ft, with record storm total of 97.8 in. at Mt. Washington, N.H. Heaviest in Massachusetts, New Hampshire, and Maine. Many homes nearly buried. Weight of snow crushed many roofs and damaged trees and utility lines. Thousands of motorists stranded. Schools and many other activities suspended. Damage $60 milion.

BLIZZARDS

A blizzard, the most severe type of winter storm, is a combination of high winds carrying a great amount of snow, low temperatures, and poor visibility. The characteristics are (1) wind speeds of 32 miles per hour or more, (2) sufficient amounts of falling or blowing snow to lower visibility to 500 feet or less, and (3) temperature 20°F, or lower. Severe blizzard characteristics are (1) winds of 45 miles per hour or more, (2) very dense falling or blowing snow, with visibility near zero, and (3) temperature 10°F, or lower. Blizzards occur nearly every year in the northern and interior portions of the country. A very severe blizzard covering a widespread area occurs every few years.

SOME OUTSTANDING BLIZZARDS

1867 December, North Dakota

Wagon train of 45 wagons and men caught in blizzard of 50 hours duration. Visibility reduced to 5 feet. 21 oxen perished.

1886 January 6–13, Iowa-Nebraska-Kansas-Oklahoma-Texas

Called "Great Blizzard" in Kansas. Struck with no advance warning. Wind averaging 40 mi/h (miles per hour) drifted snow and reduced visibility to about 15 feet. Temperatures near zero. 20 deaths reported in Iowa, and 50 to 100 in Kansas. An estmiated 80 percent of cattle in Kansas perished; heavy livestock losses reported in other states.

1888 January 11–13, Wyoming-Montana-North Dakota-South Dakota-Minnesota-Nebraska-Kansas-Oklahoma-Texas.

Reported as most disastrous blizzard ever known in Montana, the Dakotas, and Minnesota. Combination of gale winds, blowing snow, and extremely rapid drop in temperatures made storm very dangerous. Thousands of cattle perished and loss of human life was great.

1888 March 11–14, Eastern Seaboard

Unseasonably late heavy snowstorm under blizzard conditions from Chesapeake Bay area to Maine. Complete disruption of normal activity in D.C., Philadelphia, New York City, and Boston. Wind averaged 20 to 25 mi/h throughout area for 4 days. At times winds reached 50 to over 70 mi/h and blew 2- to 4-ft snowfall into drifts up to 20 ft high or more in many sections. Snowfall averaged 40 in. or more over southeastern New York and southern New England, with 50 in. at Middletown, Conn., a record storm total for the state. In New York City alone, 200 deaths, uncounted injuries, and damage near $20 million. Total deaths over 400; maritime losses over $1/2 million; railroad and business losses totaled several million dollars.

1899 February 11–14, Middle and North Atlantic States

Great eastern blizzard. Snowfall from 15 to over 40 in. from Virginia to southern New England. Near Atlantic City and Philadelphia, snowfall 44 in.; Washington, D.C., 20.5 in. (with alltime record snow depth of 34.2 in.); New York City, 24 in. Drifts to 15 ft high. Intense below-zero cold: −30°F at Woodstock, Vt.; −17°F at Rivar Vale, N.J.; and −15°F at Washington, D.C. (lowest ever recorded). Wind speeds 40 to more than 70 mi/h.

1918 January 11–12, Illinois-Indiana-Michigan-Ohio-Kentucky

Snowfall 1 to 3 ft, wind speeds 40 to more than 65 mi/h for about 15 hours, badly drifting snow, and temperatures falling rapidly to below zero caused one of the most general and complete transportation paralyses in history of Illinois, Indiana, Michigan, and Ohio. Rural mail delivery suspended for 10 days in many areas.

1940 November 11–12, South Dakota-Nebraska-Minnesota-Iowa-Wisconsin-Michigan

Armistice Day blizzard. One of most destructive blizzards of record in western and northern Iowa, and very disastrous and widespread in Michigan and Minnesota; subzero temperatures, high winds, severe drifting of snow, and visibility at times reduced to zero. There were 73 deaths in Michigan (69 in ships on Lake Michigan), 49 in Minnesota, 13 in Wisconsin, 7 in Iowa, and 2 in South Dakota. Damages exceeded $6 million, including about $1 million loss of livestock and $1.5 million damage to orchards, mostly in Iowa.

1949 January 1–6, Idaho - Nevada - Utah - Montana - Wyoming-Colorado-North Dakota-South Dakota-Nebraska

One of most severe blizzards of record in the Great Basin, middle Rockies, and northwestern Great Plains. Snowfall from 7 to more than 30 in. (41-in. state record at Chadron, Nebr.); winds 40 to 70 mi/h, snow drifted badly and reduced visibility to less than 5 feet most of 3rd and 4th in many areas, especially at Rapid City, S. Dak.; temperatures below zero. Roads blocked; farms, towns, and livestock isolated by deep snow and drifts 10 to 30 ft high. Airlift brought medical supplies and food to isolated communities and hay to starving livestock. Deaths: 12 in Wyoming, 7 in Colorado, and 20 in Nebraska. Expenditures for relief operations, and for opening and reopening roads ran to millions of dollars. Livestock losses heavy—in excess of $9 million in Wyoming alone.

1957 March 22–25, Nebraska-Kansas-Texas-New Mexico-Oklahoma

One of worst spring blizzards of record. Blowing snow reduced visibility to zero much of time. Snowfall of from 5 to more than 20 in. Drifts of 20 to 30 ft in Kansas and Texas, and 10 ft in New Mexico halted transportation and isolated some communities. 10 deaths each in Kansas and Texas, 5 in Oklahoma, 3 in Nebraska, and 1 in New Mexico. Heavy loss of livestock. Total damage about $6 million.

1966 January 29–31, Lower Appalachians-Virginia to New York-New England

Snowfall 1 to 3 ft; persistent winds of from 30 to more than 60 mi/h. Snow drifts to over 20 ft; low temperatures subzero to midteens southward to central Georgia. Transportation at standstill; thousands marooned; schools closed several days to a week. Over 50 deaths. Cost of snow removal millions of dollars. Snowfall 16 in. and drifts to over 10 ft in Washington, D.C.; schools, most Federal Offices, and businesses closed at least 1 day.

1966 March 2–5, Dakotas-Minnesota-Nebraska-Adjacent Areas

Continued unabated 4 days some areas. Snowfall to 3 ft. For several days winds averaged 30 to 50 mi/h with gusts to more than 100 mi/h. Drifts to over 30 ft; visibility near zero 3rd and 4th; low temperatures—0° to 10°F. At least 15 deaths. Traffic paralyzed; schools and businesses closed; buildings, trees, antennas damaged; over 100,000 head of livestock lost. At Bismarck, N. Dak., visibility zero from 2 a.m. to 1 p.m. on 3rd (11 hours); persistent snowstorm from 2 p.m. on 2nd to 8 p.m. on 4th with 22.4-in. record storm total.

ICE STORMS (GLAZE)

Ice storms (also referred to as freezing rain and glaze) are characterized by rain falling from warm (32°F or above), moist air aloft through colder air to the surface of the earth where temperatures are at or below the freezing point. The rain (supercooled water) freezes on impact with vegetation or other cold surfaces, and spreads a coating of ice over trees, wires, roofs, highways, streets, and walks. Ice storms generally occur from November through March in the conterminous United States. Their occurrence is not limited to the northern part of the country. Some of the most destructive of these storms have occurred in the southern States. They usually occur on from 5 to 15 days a year from the Great Plains eastward over northern and central portions of the country to the New England coast and in the northern portions of the Rockies and Cascades (map 30). Occurrence decreases to less than 1 day a year in the Far Southwest, gulf coast areas, and southern Georgia, with none in southern Florida. The region of greatest prevalence is Minnesota, Wisconsin, Michigan, and from Pennsylvania to Maine.

Ice forming on exposed objects generally ranges in thickness from that of a thin glaze to about an inch. Ice up to 8 inches in diameter was reported on wires in northern Idaho on January 1–3, 1961, up to 6 inches in diameter both in northwestern Texas on November 22–24, 1940, and in New York and Pennsylvania on December 29–30, 1942. It has been estimated that an evergreen tree 50 feet high with an average width of 20 feet may be coated with as much as 5 tons of ice during a severe ice storm. A heavy accumulation of ice, especially when accompanied by strong winds, causes great destruction of trees and transmission lines. Sidewalks, streets, and highways become a serious hazzard to pedestrians and motorists. Over 85 percent of the deaths resulting from this type of storm are attributable to traffic accidents.

SOME OUTSTANDING ICE STORMS

1921 November 26–29, Great New England Ice Storm

Most severe ice storm to date. Loss of telephone, telegraph, and electric poles and wires totalled over $5 million. Over 100,000 trees ruined; damage estimated $5 to $10 million.

1922 February 21–22, Wisconsin-Michigan

Ice storm in Wisconsin called most remarkable, most spectacular, and most destructive of its kind since official weather observations began, and in Michigan probably worst or record. Ice diameter on wires up to 4 in., icicles to 12 in. long; ice coated telephone wire 1-ft long weighed 11 pounds. Losses in Wisconsin $10 million and in Michigan $5 to $7 million. One person killed in Wisconsin.

1944 January 13–14, Texas-Louisiana-Mississippi

Considerable ice damage to timber, shrubbery, and telephone and electrical services. In Texas, considerable damage to utilities and an estimated $16 million damage to timber. In Louisiana and Mississippi, total damage $1.5 to $2 million.

1948 January 24–31, Arkansas-Mississippi-South Carolina

Considerable damage in Mississippi and South Carolina, and $20 million in Arkansas—mostly to forests and utilities. At least 29 deaths in Arkansas and 2 in South Carolina.

1951 January 28–February 4, Texas-Arkansas-Louisiana-Mississippi-Alabama-Tennessee-Kentucky-Indiana-Ohio-West Virginia-Virginia-Pennsylvania-New England

Probably the most destructive ice storm in the United States. Ice on exposed objects ½ to 4 in. thick. Buildings collapsed; trees, shrubbery, wires, and poles damaged. Extensive damage in Texas, about $50 million in Mississippi, $15 million in Louisiana, $1.75 million in Tennessee, and heavy damage in Ohio. Mississippi 16 deaths, Louisiana 4, Alabama 2, Pennsylvania 6, West Virginia 1, and New England 7. Hundreds injured on ice-coated walks, streets, and highways.

1953 January 8–11, Maryland-Pennsylvania-NewJersey-New York-New England

Ice on wires and trees, 1 to 3 in. thick, broke many trees, and communications and powerlines. Damage $2.5 million in New England, $1.5 million in New Jersey, $100,000 in Maryland, and $43,000 in Pennsylvania. 31 deaths in New England and 7 in New Jersey. Many injured in traffic accidents and falls. State of emergency declared at Norwalk, Conn.

1960 March 1–2, Texas-Louisiana-Arkansas-Tennessee-Alabama-Georgia-South Carolina-North Carolina

Most severe ice storm in memory in Alabama. Roofs collapsed, and timber, telephone lines, and powerlines damaged. Damage in Tennessee about $3.5 million, Arkansas over $1 million, Alabama and Georgia over $5 million each, and hundreds of thousands of dollars each in Louisiana, North Carolina, and South Carolina. At least 5 deaths in accidents on icy roads.

1963 December 31–January 1 (1964), Georgia-South Carolina-Adjacent Areas

Widespread freezing rain coated roads, wires, poles, trees, and shrubbery, followed by sleet and snow in central and northern portions. Traffic stalled 1 to 3 days on many roads; heavy damage to power and communication lines and trees; schools closed. Damage over $7 million. A few deaths. In Georgia, 3,400 poles downed.

1965 December 11–12, Dakotas-Minnesota

Ice 3 in. or more in diameter on wires and twigs. Damage most severe in eastern Dakotas, exceeding $2 million to telephone and powerlines in South Dakota alone. Glaze remained a week in many areas. Travel interrupted. Schools closed.

1969 February 15–17, South Carolina

Severe damage to timber, shrubbery, and telephone and electric services from Lancaster to Dillon and Marion Counties and southward to Orangeburg County. Miles of poles and lines down. Loss of timber alone $60 million. At least 3 deaths.

1970 January 17–19, Oregon

Ice accumulated up to 1.5 in. thick on trees, wires and other objects in Hood River County and Columbia Gorge. Damage to orchards alone about $6 million.

Chapter 6

Severe Local Storms

Thunderstorms, tornadoes, and waterspouts are small, but intense local storms. Tornadoes occur primarily with thunderstorms and occasionally with hurricanes, but only under specific atmospheric conditions. Waterspouts, which are akin to tornadoes, can and do occur without the presence of thunderstorm clouds, and are much less destructive than tornadoes.

Most thunderstorms are accompanied by strong wind, lightning, heavy rain, and, occasionally, hail. Thunderstorm gusts can reach speeds in excess of 65 miles per hour, lightning can and does start forest fires and strike buildings and people, and hail annually destroys crops valued at millions of dollars. The strong, whirling wind and the sudden pressure drop accompanying the passage of a tornado are responsible for a relatively heavy annual loss of life and severe property damage.

THUNDERSTORMS

Thunderstorms are most frequent during the warm part of the year. The area of greatest occurrence in the United States extends eastward from Wyoming, Colorado, and New Mexico and includes the entire central and southern sections of the country (map 31). The annual frequency of thunderstorms ranges from a high of 80 to more than 100 over the Florida Peninsula to a low of from 2 to 5 along the Pacific Coast. In the South, thunderstorm activity is most frequent during the afternoon; in the Great Plains and the Upper Mississippi Valley, activity is greatest at night.

In Alaska, the annual frequency of thunderstorms ranges from 5 to 10 days a year in the interior valleys to 1 day or less a year over the Gulf of Alaska coast and island areas. A few summer thunderstorms have occurred along the Arctic coast at Point Barrow and Barter Island, but in insufficient number to establish an annual frequency as great as 1 per year.

Thunderstorms of moderate intensity occur at several locations in Hawaii on an average of 5 to 10 days a year.

In Puerto Rico, the annual rate of occurrence of thunderstorms is about 50 per year on the east, north, and northwest coasts, fewer than 50 on the south coast, and more than 50 in the heavy rainfall areas of the interior.

LIGHTNING

Thunderstorm lightning is perhaps one of the most dangerous of natural phenomena. During an average year, lightning kills more than 150 people and injures more than 1,000, and is the cause of property losses in excess of $100 million in the United States alone.

During periods of dry weather, lightning strikes are responsible for about 75 percent of the brush and forest fires occurring in the Far West. On August 23 and 24, 1970, fires started by lightning during hot, dry, windy weather caused more than $50 million in damages, mostly to timber, in the Wenatchee and Okanogan National Forests of Washington. The most damaging lightning strike on record hit the U.S. Naval Depot at Lake Denmark, N.J.; property loss was $93 million.

At any minute of the day or night there are between 1,800 and 2,000 thunderstorms in progress over the surface of the earth. The National Weather Service offers these safety rules to be followed when lightning threatens:

1. Don't venture outside unless absolutely necessary.
2. Stay away from open doors and windows, fireplaces, radiators, stoves, metal pipes, sinks, and connected electrical appliances.
3. Don't use electrical equipment such as hair dryers, toothbrushes, or razors.
4. Don't use the telephone during storm, because lightning may strike lines outside.
5. Don't take laundry off clothesline.
6. Don't work on fences, telephone, or structural steel fabrication.
7. Don't use metal objects such as fishing rods and golf clubs.
8. Don't handle flammable materials in open containers.

9. Stop tractor work, especially if machine is pulling metal equipment.
10. Get out of water and off of small boats.
11. Stay in the vehicle if you are traveling. Autos offer excellent protection.
12. Seek shelter in buildings. If none is available, best protection is a cave, ditch, canyon, or under head-high clumps of trees.
13. If there is no shelter, avoid the highest object in the area. If only isolated trees are nearby, best protection is to crouch in the open.
14. Avoid hilltops, open spaces, wire fences.
15. If you feel an electrical charge—if hair stands on end or skin tingles—lightning may be about to strike you. Drop to the ground immediately.

Immediate treatment should be given to restore heart action and respiration in a person who has been struck by lightning, even though he appears to be dead. The victim may recover; such recoveries are usually complete. There is no danger in touching a person who has been struck by lightning, because the body does not retain an electrical charge.

Lightning also has some beneficial effects. When lightning passes through the atmosphere it causes oxygen and nitrogen in the path of the stroke to combine into oxides of nitrogen. These compounds, which are first-rate fertilizers, are flushed out of the air and into the soil by rain. It is estimated that, in areas of moderate to heavy thunderstorm activity, from 1 to 4 pounds of nitrogen falls on each acre of soil each year. Lightning also shatters water molecules causing the formation of ammonia compounds of oxygen, hydrogen, and nitrogen. These, too, are excellent fertilizers.

HAILSTORMS

Hailstorms are produced by thunderstorms; most occur during the warmer part of the year. Most hailstorms produce small stones and some are very destructive. In the conterminous United States, annual property and crop losses caused by hail are estimated at $300 million. In the Great Plains, where damage to crops is heaviest, crop-hail insurance costs farmers more than $110 million annually.

Hail occurs most frequently in the west-central section of the Great Plains (map 32). The annual average for most places in this area is 4 to 6 hailstorms; the maximum for the area—8 hailstorms a year—was reported at Cheyenne, Wyo. Hail is least frequent in the following locations: along the Atlantic and gulf coasts; in the area between Reno, Nev., and Yuma, Ariz.; in the Puget Sound area and over the southeastern section of Washington; and in the Willlamette Valley of Oregon, where hail occurrences are rare.

The fall of hail in Alaska is confined mainly to the interior valleys; the occasional hail occurrences are of little consequence. In Hawaii, hail is infrequent and seldom significant. In Puerto Rico, hail occurs about once a year. Hailstones here are usually pea-sized, but there have been a few reports of hailstones as large as 1 inch in diameter. Usually there is no damage from hailstorms, but damage amounting to several thousands of dollars has been reported for Puerto Rico.

Hailstorms caused $20 million worth of damage in Oklahoma City on May 23 and 24 in 1968. Damage caused by a hailstorm in Amarillo, Tex., on June 17, 1969, totalled $15 million; about 25,000 homes and 6,000 automobiles were severely damaged during the storm. During 1951 an unusual number of severe hailstorms in Kansas caused an estimated $31 million in damages, mostly to crops. During 1969, hailstorms in Iowa caused more than $25 million damage. On June 18, 1970, hailstones, ¼- to ½-inch in diameter, driven by strong winds, cut wheat and corn almost to the ground along a swath 4- to 8-miles wide and 200-miles long through southwestern Nebraska; losses were estimated at $5 million. On July 14, 1970, a hailstorm caused over $11 million damage in Turner and Lincoln counties in South Dakota; hailstones in this storm were mostly 1 to 2 inches in diameter with a few as much as 5 inches in diameter. A freak hailstorm, one of the most severe ever recorded, occurred at Seldon, Kansas, on June 3, 1959. Hail fell between 5:15 and 6:40 p.m. Pea-sized to marble-sized hail covered the ground with accumulations as deep as 15 to 18 inches in places; most of the hail fell within a 4-mile radius of Seldon.

Most of the hail that falls is pea-size to marble-size; stones as large as golfballs are reported often, and stones as large as baseballs also are reported, but rather infrequently. Spherical hailstones with diameters as great as 4 inches, and a few saucer shaped stones 7 to 9 inches in diameter, were reported in the hailstorm of May 10, 1970, near Wichita, Kansas. What may have been the largest stone on record for the United States fell at Coffeyville, Kansas on September 3, 1970. It weighed 1.67 pounds and was 17.5 inches in circumference. The heaviest stone ever reported was the 3-pound stone reported by the USSR.

The only known hail death in the United States (up to 1971) occurred on May 13, 1930, when a farmer out in a field near Lubbock, Tex., was caught in a hailstorm and was literally beaten to death by hail before he could reach shelter.

TORNADOES

Tornadoes are perhaps the most destructive of storms. Striking suddenly, their strong winds can uproot trees, lift houses off foundations, twist structural steel frames, and cut swathes of destruction as they pass through an

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area. The tornado funnel is an elongated, whirling cloud that extends downward from the base of a severe thunderstorm, sometimes touching the ground, sometimes skipping from point to point as it extends to the earth's surface and then withdraws toward the base of the parent thunderstorm.

The destructive elements of a tornado are the strong winds, the heavy rain, the hail, the lightning, and the pressure drop within the funnel. The winds whirling cyclonically around the storm may reach speeds in excess of 200 miles an hour, rain usually is excessive but short in duration, hail bourne by the winds of the storm can penetrate like bullets, and lightning can be almost continuous. When the low pressure of a tornado envelops a closed house the higher pressure inside pushes outward, causing the house literally to explode.

The usual forward motion of a tornado is about 25 to 40 miles per hour. But a tornado can remain stationary, change direction, or move as fast as 60 miles per hour. Most tornadoes move from the west or the southwest toward the east or northeast, but a tornado can move in any direction. Half of all tornadoes reported travel less than 5 miles along the ground; a few have been tracked over distances in excess of 200 miles. The mean width of the path of destruction of tornadoes is 250 yards; the actual widths vary from a few feet to about 1 mile.

A tornado can occur any day of the year at any time of the day or night. Records show that April, May, and June are the preferred months, and 2:00 p.m. to 7:00 p.m. are the preferred times. Maximum tornado activity starts in the deep South during the late winter and early spring months, and moves northward into the central and northern plains with maximum activity during April, May, and June. During the period 1953 through 1971, the mean annual number of tornadoes reported over the conterminous United States was 655. These occurred on an average of 161 days each year, and caused an average of 118 deaths, 2,000 injuries, and $200 million in property damage annually. During this same period an average of 450 funnel clouds that did not touch the ground were reported each year.

Tornadoes have been reported in every state (map 33). They are rare west of the Continental Divide and

TORNADO SAFETY RULES:

Seek inside shelter, preferably in a tornado cellar, underground excavation, or a steel-framed or reinforced concrete building of substantial construction. Stay Away From Windows.

In Cities or Towns--In office buildings, stand in an interior hallway on a lower floor, preferably in the basement.

In Factories—on receiving a tornado warning, post a lookout. Workers should move quickly to the section of the plant offering the greatest protection in accordance with advance plans.

In Homes—the basement usually offers the greatest safety. Seek shelter under a sturdy workbench or heavy table if possible. In a home with no basement, take cover under heavy furniture in the center part of the house. Keep some windows open, but stay away from them. Mobile homes are particularly vulnerable to overturning during strong winds. Trailer parks should have a community shelter. Appoint a community leader responsible for constant radio monitoring during threatening weather or during watch periods.

In Schools—whenever possible, go to an interior hallway on the lowest floor.
Avoid Auditoriums and Gymnasiums or other structures with wide free-span roofs.

If a building is not of reinforced construction, go quickly to a nearby reinforced building or to a ravine or open ditch and lie flat.

In Open Country—move away from the tornado's path at a right angle. If there is no time to escape, lie flat in the nearest depression, such as a ditch or ravine.

Tornado Watch means tornadoes are expected to develop.

Tornado Warning means a tornado has actually been sighted.

Keep Listening—Your radio and television stations will broadcast the latest tornado advisory information. Call the local National Weather Service Office only to report a tornado.

in mountainous areas. The area of most frequent occurrence is east of the Rockies over central and southern sections of the Great Plains; nearly one-third of all tornadoes ever reported in the United States have occurred within the boundaries of Kansas, Oklahoma, and Texas. During the period 1916 through 1971, 8 tornadoes that caused 100 or more deaths each were reported.

Although tornadoes are small it is not unusual for certain places to be struck again and again. Two tornadoes occurred within 25 minutes of each other at Baldwyn, Miss.; Austin, Tex., was struck twice within 30 minutes. Codell, Kans., was struck on three successive years—1916, 1917, and 1918. Tornadoes struck Tinker Air Force Base, Okla., 5 days apart, on March 20 and 25, 1948. The first of these destroyed 50 military aircraft and damaged 50; the loss was $10 million. The second storm destroyed another 35 planes and damaged 40. At least 18 large cities have been struck by 6 or more tornadoes. During the period 1916 through 1970, Oklahoma City was struck 18 times, and St. Louis, Mo., 10 times.

Series of tornadoes have been known to occur with a single storm system. During a 66-hour period on May 25 through 27, 1955, 72 tornadoes were reported in connection with a storm system that passed across Texas, Oklahoma, Kansas, Nebraska, Missouri, Arkansas, and Illinois. These tornadoes were the cause of 102 deaths and $12 million damage. The famous Palm Sunday tornadoes of April 11 and 12, 1965 consisted of a series of 47 storms that struck Illinois, Indiana, Ohio, Michigan, and Wisconsin during the early evening hours of the 11th and the early morning hours of the 12th. Two hundred and fifty seven people died and 1,600 were injured in these storms; property damage was $200 million.

Tornadoes also frequently occur with hurricanes. A record total of 115 tornadoes occurred in hurricane Beulah on September 20, 1967 as the tropical storm moved inland over the coast of Texas, The previous record of tornadoes reported during hurricanes were the 26 that occurred with hurricane Carla during the period from September 10 though 13, 1961.

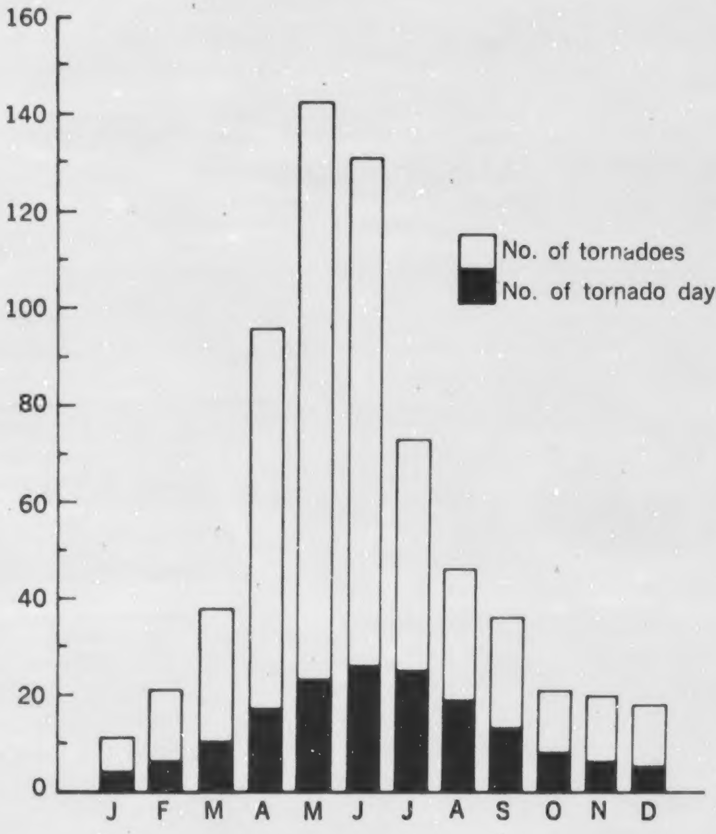

Figure 4.—Average monthly number of tornado days in the United States, 1953-71. (12,444 tornadoes reported.)

Table 5.—Number of tornadoes, tornado days, and resulting losses by years, 1916-71

Year	Number of tornadoes	Tornado days	Total deaths	Most Deaths in single tornado	Total property losses†	Number of tornadoes causing losses† in: Category 5	Category 6	Category 7 and Over
1916	90	36	150	30	6	7	1	0
1917	121	38	509	101	7	21	9	0
1918	81	45	135	36	7	20	5	0
1919	64	35	206	59	7	10	2	0
1920	87	50	498	87	7	14	10	0
1921	105	55	202	61	7	22	3	0
1922	108	64	135	16	7	27	5	0
1923	102	59	109	23	6	21	1	0
1924	130	57	376	85	7	26	11	1
1925	119	65	794	689	7	34	2	1
1926	111	57	144	23	6	28	0	0
1927	163	62	540	92	7	42	9	1
1928	203	79	92	14	7	40	7	0
1929	197	74	274	40	7	48	4	0
1930	192	72	179	41	7	38	6	0
1931	94	57	36	6	6	14	1	0
1932	151	67	394	37	7	23	1	1
1933	258	96	362	34	7	46	9	0
1934	147	77	47	6	6	10	3	0
1935	180	77	70	11	6	29	0	0
1936	151	71	552	216	7	17	5	1
1937	147	75	29	5	6	24	0	0
1938	213	76	183	32	7	29	6	0
1939	152	75	87	27	7	21	3	0
1940	124	62	65	18	7	13	2	0
1941	118	57	53	25	6	24	1	0
1942	167	66	384	65	7	42	10	0
1943	152	61	58	5	7	28	8	0
1944	169	68	275	100	7	50	9	0
1945	121	66	210	69	7	21	10	1
1946	106	65	78	15	7	29	7	0
1947	165	78	313	169	7	46	7	1
1948	183	68	140	33	7	62	11	2
1949	249	80	212	58	7	54	13	0
1950	199	88	70	18	7	47	9	0
1951	272	113	34	6	7	35	11	2
1952	236	98	230	57	7	53	19	0
1953	437	136	516	116	8	63	18	7
1954	549	159	35	6	7	63	8	1
1955	593	153	125	80	7	74	13	1
1956	532	155	83	25	7	83	24	1
1957	864	154	191	44	8	129	26	3
1958	565	166	66	19	7	70	8	1
1959	589	156	58	21	7	70	4	1
1960	618	172	47	16	7	65	11	1
1961	682	169	51	16	7	103	21	1
1962	658	152	28	17	7	51	10	0
1963	461	141	31	5	7	77	15	1
1964	713	156	73	22	7	113	17	5
1965	899	181	298	44	8	126	30	11
1966	570	150	99	58	8	79	13	4
1967	912	173	116	33	8	125	33	8
1968	661	171	131	34	8	82	26	6
1969	604	155	66	32	8	98	16	3
1970	649	171	73	26	8	97	24	6
1971	888	192	156	58	8	71	30	5
Means: 1953-71	655	161	118	—	—	86	18	3

NOTE:—The above estimated losses are based on values at time of occurrence.

† Storm damages in categories:

5. $50,000 to $500,000
6. $500,000 to $5 million
7. $5 million to $50 million
8. $50 million and over.

Table 6.—Number of tornadoes, tornado days, and deaths by States, 1953-71

	Tornadoes							Days		Deaths		
State	Total	Average	Greatest	Year	Least	Year	No.[5] per 10,000 sq. mi.	Total	Average	Total	Average	No.[6] per 10,000 sq. mi.
Alabama	314	17	45	1957	5	1956	3.20	176	9	84	4	16
Alaska	1	0	1	1959	0	[1]1971	.00	1	0	0	0	0
Arizona	57	3	7	1971	0	[1]1965	.26	51	3	2	0	0
Arkansas	311	16	37	1961	2	[1]1969	3.08	173	9	91	5	17
California	46	2	10	1958	0	[1]1968	.15	37	2	0	0	0
Colorado	263	14	38	1965	1	1959	1.33	186	10	3	0	0
Connecticut	24	1	3	[1]1968	0	[1]1969	2.53	22	1	1	0	2
Delaware	13	1	4	1967	0	[1]1971	3.26	12	1	0	0	0
District of Columbia	0	0	0	—	0	—	0	0	0	0	0	0
Florida	540	28	59	1971	13	1965	4.85	376	20	40	2	7
Georgia	365	19	46	[3]1971	7	1960	3.26	224	12	42	2	7
Hawaii	9	1	4	1971	0	[1]1970	.74	8	0	0	0	0
Idaho	22	1	5	1956	0	[1]1971	.14	21	1	0	0	0
Illinois	404	21	42	1957	6	1953	3.79	212	11	109	6	19
Indiana	411	22	48	1965	6	1953	5.98	199	10	147	8	40
Iowa	421	22	54	1964	7	1955	3.94	220	12	36	2	6
Kansas	944	50	94	1964	17	1969	6.04	431	23	131	7	16
Kentucky	116	6	16	1971	0	1953	1.51	79	4	25	1	6
Louisiana	304	16	30	1957	3	1955	3.30	194	10	73	4	15
Maine	61	3	11	1971	0	1964	.97	50	3	1	0	0
Maryland	36	2	5	1967	0	[1]1970	1.79	32	2	1	0	0
Massachusetts	85	4	12	1958	0	1959	5.39	61	3	93	5	[4]112
Michigan	209	11	24	1956	1	1959	1.89	125	7	218	11	37
Minnesota	320	17	34	1968	7	[1]1963	2.00	184	10	67	4	8
Mississippi	352	19	41	1971	5	1964	3.88	200	11	292	15	61
Missouri	563	30	71	1967	7	1953	4.25	277	15	101	5	14
Montana	66	3	10	1962	0	[1]1967	.23	56	3	0	0	0
Nebraska	637	34	54	1958	10	1966	4.34	316	17	40	2	5
Nevada	9	0	4	1964	0	[1]1969	.04	8	0	0	0	0
New Hampshire	45	2	9	1963	0	[1]1971	2.54	39	2	0	0	0
New Jersey	25	1	5	1960	0	[1]1969	1.69	22	1	0	0	0
New Mexico	172	9	17	1957	0	1953	.74	126	7	2	0	0
New York	49	3	7	1969	0	1953	.52	47	2	1	0	0
North Carolina	135	7	12	1964	2	1970	1.35	103	5	9	0	2
North Dakota	252	13	41	1965	2	1961	1.87	154	8	15	1	2
Ohio	218	11	32	1965	3	[1]1966	2.78	135	7	100	5	24
Oklahoma	1131	60	106	1957	30	1963	8.52	466	25	127	7	18
Oregon	14	1	6	1964	0	[1]1969	.08	13	1	0	0	0
Pacific[7]	0	0	0	—	0	—	0	0	0	0	0	0
Pennsylvania	105	6	23	1954	0	[1]1964	1.22	84	4	4	0	1
Puerto Rico	4	0	2	1969	0	[1]1971	.62	4	0	0	0	0
Rhode Island	0	0	0	—	0	—	0	0	0	0	0	0
South Carolina	175	9	22	[1]1965	1	1970	2.96	119	6	8	0	3
South Dakota	431	23	64	1965	1	1958	2.95	220	12	7	0	1
Tennessee	159	8	17	1957	1	1962	1.98	99	5	24	1	6
Texas	2070	109	232	1967	49	1953	4.08	868	46	286	15	11
Utah	30	2	5	1970	0	[1]1960	19	25	1	0	0	0
Vermont	21	1	5	1962	0	[1]1971	12	17	1	0	0	0
Virgin Islands	0	0	0	—	0	—	0	0	0	0	0	0
Virginia	79	4	12	1959	1	[1]1963	1.02	62	3	13	1	3
Washington	18	1	3	1971	0	[1]1968	.14	17	1	0	0	0
West Virginia	29	2	5	1967	0	[1]1960	.63	26	1	0	0	0
Wisconsin	334	18	33	1964	3	1953	3.13	190	10	49	3	9
Wyoming	111	6	17	1962	0	1970	.60	94	5	1	0	0
United States	[2]12444	655	912	1967	437	1953	1.81	[3]3062	161	2243	118	6

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[1] Also in earlier year(s).

[2] Corrected for boundary-crossing tornadces.

[3] Tornado days for country as a whole.

[4] Ninety deaths in Worcester tornado of June 9, 1953.

[5] Mean annual number.

[6] For period 1953-71.

[7] Trust territories, Pacific islands.

Table 7.—Some oustanding tornadoes since 1900

Date			Place	Time of occurrence	Dead	Injured	Estimated property damage **
1900	Nov.	20	Ark., Miss., Tenn.	Afternoon-evening	73	many	$0.5
1902	May	18	Goliad, Tex.	—	114	250+	0.05
1903	June	1	Gainesville Ga	12:45 pm	98	190	1.0
1905	May	10	Snyder, Okla.	6:45– 8:45 pm	87	49	0.02
1908	Apr.	24	Lamar & Wayne Cos., Miss.	3:00 pm	100	649	.88
1909	Mar.	8	Dallas & Monroe Cos., Ark.	5:00– 7:10 pm	64	671	.66
1913	Mar.	23	Omaha, Nebr.	5:49 pm	95	—	3.5
1916	June	5	Ark. (series of tornadoes)	1:00 pm	83	400	*
1917	May	26	Mattoon & Charleston, Ill.	3:26 pm	101	638	2.5
1917	May	27	Lake Co., Tenn. & Fulton, Hickman, Carlisle, & Graves Cos., Ky.	4:00– 9:00 pm	70	—	2.0
1919	June	22	Fergus Falls, Minn.	4:45 pm	59	—	3.5
1920	Mar.	28	Ala. & Ga.	2:30– 4:00 pm	50	—	1.4
1920	Apr.	20	Oktibbeka Co., Miss. & Franklin Co., Ala.	9:00 am	87	—	1.5
1920	May	2	Rogers, Mayes, & Cherokee Cos., Okla.	6:00– 8:35 pm	64	—	0.18
1921	Apr.	15	Cass Co., Tex. & Miller, Hempstead, & Pike Cos., Ark.	4:00 pm	61	—	1.3
1924	Apr.	30	Central S.C.	7:30 am	67	—	1.0
1924	June	28	Lorain & Sandusky, Ohio	4.35 pm	85	—	12.0
1925	Mar.	18	Mo., Ill., Ind. (Tri-State)	1:00– 4:00 pm	689	1,980	17.0
1926	Nov.	25	Belleville to Portland, Ark.	4:30– 9:30 pm	53	—	0.63
1927	Apr.	12	Rock Springs, Tex.	7:45 pm	74	—	1.23
1927	May	9	Randolph Co., Ark. & Poplar Bluff, Mo.	2:05– 3:20 pm	92	—	2.3
1927	Sept.	29	St. Louis, Mo.	1:00 pm	72	—	22.0
1932	Mar.	21	Ala. (series of tornadoes)	3:15– 7:00 pm	268	1,874	5.0
1936	Apr.	5	Tupelo, Miss.	8:55 pm	216	700	35.0
1936	Apr.	6	Gainesville, Ga.	2:27 am	203	934	13.0
1942	Mar.	16	Central to N.E. Miss.	4:00 pm	75	525	1.4
1942	Apr.	27	Rogers & Mayes Cos., Okla.	3:45 pm	52	181	2.0
1944	June	23	Ravenna, Ohio, Pa., W. Va. to Cumberland, Md.	6:00– 9:30 pm	150	867	4.2
1945	Apr.	12	Okla. & Ark.	3:25– 6:00 pm	102	689	4.0
1947	Apr.	9	Texas, Okla. & Kans.	6:00–10:00 pm	169	983	9.8
1949	Jan.	3	La. & Ark.	3:00– 6:00 pm	58	439	1.5
1952	Mar.	21 -22	Ark., Mo., Tenn. (series of tornadoes).	3:00–12:00 pm	208	1,154	14.0
1953	May	11	Waco, Texas	4:10 pm	114	597	41.0
1953	June	8	Flint to Lakeport, Mich.	8:30–10:30 pm	116	867	19.0
1953	June	9	Central & Eastern Mass.	3:25– 5:00 pm	90	1,288	52.0
1953	Dec.	5	Vicksburg, Miss.	5:35 pm	38	270	25.0
1955	May	25	Udall, Kans.	10:30 pm	80	270	2.2
1957	May	20	Williamsburg, Kans. to Ruskin Heights, Mo.	6:15– 8:30 pm	44	531	*
1965	Apr.	11 -12	Ind., Ohio, Mich., Wis., & Ill. (series of 47).	Evening-morning	257	1,600	200.0
1966	Mar.	3	Miss. & Ala. (esp. Jackson, Miss.)	Afternoon	58	531	18.5
1966	June	8	Topeka, Kans. & vicinity	7:15 pm	16	406	100.0
1970	May	11	Lubbock, Texas	8:35 pm	26	500	135.0
1971	Feb.	21	Mississippi	Afternoon-night	107	1,060	17.2

* No estimates available

** In millions

WATERSPOUTS

Waterspouts are tornado-like phenomena that occur over water. A waterspout may be a tornado that has moved off the land surface to over a water surface, but usually it has formed over water. Waterspouts generally are less intense than tornadoes and tend to form with cumulus clouds rather than requiring the presence of cumulonimbus (thunderstorm) clouds. Some waterspouts apparently form under clear sky conditions. These are more in the nature of land-based dust devils, small in size and short lived. Waterspouts are observed over both inland waters and along the coast of the United States. About 40 per year were reported mostly off the South Atlantic and gulf coasts during the period 1948 through 1970.

TROPICAL CYCLONES—HURRICANES

Tropical cyclones in their most intense stage of development are called hurricanes. When the winds of a tropical cyclones are less than 39 miles per hour (34 knots), the storm is known as a *tropical depression*. With winds from 39 miles per hour (mi/h) to, but not including, 74 mi/h (64 knots), the name *tropical storm* is used. After winds reach 74 mi/h, the storm is called a *hurricane*. Hurricanes hit the United States mainly along the Atlantic and Gulf coasts, but occasionally come onshore along the southern coast of California.

Hurricanes are normally about 200 miles in diameter. The destructive elements of a hurricane are the winds, the storm tides, the torrential rains, and the occasional tornadoes that accompany these storms. The winds, which often exceed 100 mi/h, cause great difficulties for ships at sea and can cause heavy damage over land areas. A large part of the damage and more than three-fourths of the loss of life attributed to hurricanes have been caused by storm tides. The hurricane storm tide, or storm surge as it is sometimes called, floods coastal areas with seas as much as 15 or more feet higher than normal high tides. Over land rainfall brought by hurricanes has often caused severe flooding over extensive areas. Tornadoes in hurricanes often are more dangerous than the usual thunderstorm tornado because the hurricane clouds tend to hide the funnel until it is too late to give warming. Also, tornadoes in hurricanes often occur at night and so can strike with little warning.

Hurricanes of the tropical Atlantic and the Caribbean at first move slowly westward gradually increasing in strength. Then they usually "recurve," first to the north, and then to the northeast. Sometimes they go ashore over the Atlantic or the Gulf Coast states; sometimes they continue to move westward and go ashore over Central America or Mexico. If the recurvature takes place far enough to the east, the hurricane misses the East Coast altogether and moves northeastward into the central North Atlantic. The movement of a tropical cyclone is often erratic. A hurricane on the move can slow down, remain nearly stationary, speed up, or change direction. Usually the storm will move slowly (10 to 20 mi/h forward speed) during its developing stages, will slow down during its most intense stage, and will speed up after recurvature to forward speeds of 40 mi/h or more.

On the average, 4 tropical cyclones will reach the mainland of the United States each year; 2 of these storms will be hurricanes. In some years as many as 9 of these storms have hit the mainland of the United States; in other years none have hit. Every year tropical cyclones of the eastern Pacific, which generally form off the west coast of Central America or Mexico, bring very high tides to the West Coast and heavy rains to the Pacific or Southwest States. Sometimes a tropical storm will move inland over the Southwest.

Six hurricanes have passed over Puerto Rico between 1893 and 1971. The storm of August 8, 1899, caused the loss of 3,000 of 3,542 lives lost on Puerto Rico during the 79-year period of record. Many storms that just missed the island brought damaging winds and heavy rains. One such storm was hurricane Donna which passed close to Puerto Rico on September 5, 1960. Donna caused flash floods, 107 deaths, and the loss of millions of dollars worth of crops and property in Puerto Rico.

Hawaii has been affected by hurricanes only 5 times in the 68-year period between 1904 and 1972. Hurricane Dot, the only tropical storm known to have crossed the State passed northward over Kauai early in August 1959 and caused $6 million damages. Tropical cyclones pass sufficiently close to the islands to cause heavy rains and moderate to strong winds on Hawaii once every 3 to 4 years.

Table 8.—Some outstanding hurricanes

Dates affecting U.S.	Areas most affected	Deaths	Estimated damage (in millions)	Remarks
1900 Sept. 8-11	Texas	6,000	$25	Most damage and loss of life caused by storm tide which inundated Galveston Island. Wind blew off anemometer at 77 mi/h and gusts 120 mi/h.
1909 Sept. 20-21	Louisiana and Mississippi	350	5	Hurricane center passed 50 to 75 miles west of New Orleans. Most of Louisiana coast inundated.
1915 Aug. 16-23	Texas and Louisiana	275	50	Twelve-foot storm tide inundated Galveston to a depth of 6 feet. Maximum mum wind of 92 mi/h and gusts 120 mi/h at Galveston.
1915 Sept. 29-Oct 1	Middle Gulf Coast	275	13	Over 90% of buildings destroyed over large area of Louisiana south of New Orleans. Maximum wind 106 mi/h at Burrwood, La.
1919 Sept. 14-15	Florida, Louisiana and Texas	287	22	Maximum wind 72 mi/h at Sand Key, Fla. Hurricane severe in Florida and Texas.
1926 Sept. 20-22	Florida and Alabama	243	73	Very severe in Miami area and from Pensacola into southern Alabama. Extreme wind speed of 152 mi/h recorded at Pensacola, Fla. on 20th.
1928 Sept. 16-20	Southern Florida	1,836	25	Wind-driven waters of Lake Okeechobee overflowed into populated areas, causing most of the casualties.
1935 Sept. 2-6	Southern Florida	408	6	"Labor Day Storm"—barometric low of 892.3 mb (26.35 inches) at Lower Matecumbe Key is lowest of record in Western Hemisphere. Wind reached about 200 mi/h on Keys.
1938 Sept. 21-22	Long Island, N.Y. southern New England	600	306	Very heavy wind and storm surge damage in most of New England. Maximum wind 121 mi/h and gusts 183 mi/h at Blue Hill, Mass. Hurricane's forward speed up to 56 mi/h.
1954 Aug. 30-31 (Carol)	North Carolina to New England	60	439	Maximum wind 100 mi/h and gusts 135 mi/h at Block Island, R.I. Extremely high tides flooded many low-lying areas in New England. Greatest property loss in single storm to this date.
1954 Oct. 15 (Hazel)	South Carolina to New York	95	200	Maximum winds 82 mi/h at Wilmington, N.C., 113 mi/h at New York City, Unusually heavy damage in exposed North Carolina shore areas due to wave action

Table 8.—Continued

				super-imposed on high tides. Storm retained destructive intensity through Middle Atlantic States.
1955 Aug. 16-20 (Diane)	North Carolina to New England	184	832	Heavy rainfall with near maximum run-off caused general severe floods of entire northeast United States. Damage exceeded any previous hurricane of record in United States. Wind gusts to 83 mi/h Wilmington, N.C.
1957 June 26-29 (Audrey)	Texas to Alabama	390	138	Winds 85 mi/h and gusts 100 mi/h at Sabine Pass CG, Tex. Storm surge over 12 feet caused inundation of flat Louisiana coast with Gulf waters as far as 25 miles inland in some areas. Many homes destroyed; offshore oil installations heavily damaged. Thousands of cattle drowned. Cameron and Lake Charles, La., and Port Arthur, Tex. hardest hit.
1960 Sept. 9-13 (Donna)	Florida to New England	50	$ 426	Highest wind speed 95 mi/h and gusts 130 mi/h at Block Island, R.I.; 92mi/h at Ft. Myers, Fla. Winds estimated about 140 mi/h and gusts about 180 mi/h on central Florida Keys. First storm with hurricane winds in Florida through Middle Atlantic States and New England in 75 years.
1961 Sept. 11-14 (Carla)	Texas	46	408	Most extensive and severe Gulf coast hurricane in many years. Severe damage on wide expanse of Texas coast.
1965 Sept. 7-12 (Betsy)	Southern Florida, Alabama, Mississippi and Louisiana	75	1,420	Record damage for a single hurricane; much of damage caused by flooding, especially in Louisiana. Wind speeds reached 140 mi/h on Key Largo, Fla. on the 8th, and 125 mi/h at New Orleans on the 9th.
1967 Sept. 19-22 (Beulah)	Texas	15	208	Severe flooding and record number of 115 tornadoes. Third most destructive storm ever in Texas.
1969 Aug. 17-20 (Camille)	Mississippi, Louisiana, and Virginias	324	1,420	Struck Mississippi coast Aug. 17 with winds up to 200 mi/h and tides up to 24 ft. Record-breaking rainfall and floods in southwestern Virginia. Equalled record damage for a single hurricane.
1970 Aug. 3-5 (Celia)	Texas	11	453.8	Gusts to 161 mi/h as it moved inland across Corpus Christi Bay. Corpus Christi, Port Aransas, and Aransas Pass hardest hit. Tide to 9.2 ft. above mean sea level. Rainfall to 7.24 inches at Robstown. Eight tornadoes. Damage

Table 8.—Continued

				$334.2 million in Nueces Co., mostly in Corpus Christi. Gusts to 89 mi/h as far inland as Del Rio with $1 million damage.
1972 June 18–25 (Agnes)	Florida to New York	117	2,103.6	Costliest hurricane in U.S. history, although storm reduced to tropical storm intensity after passage inland. Damage mostly from devastating floods. Deaths, and damage (in millions): Pennsylvania, 48, $1,243; New York, 24 $653; Maryland, 19, $74; Virginia, 13, $84; Florida, 9, $12.4; New Jersey, 1, $15; Ohio, 0, $3.3; Delaware, 1, light; West Virginia, 0, $12.3; and North Carolina, 2, $6.6. Damage in Florida includes $4.5 caused by 15 tornadoes.

Table 9.—Some outstanding extratropical cyclones*

Dates affecting U.S.	Areas most affected	Deaths	Estimated damage (in millions)	
1950 Nov. 24–26	Eastern United States	200	100	Storm broke many November snowfall and low temperature records from Lower Great Lakes region southward to Mississippi, Alabama, Georgia, and South Carolina. Gale force winds of record duration, accompanied by flood producing rains (2 to over 6 inches) and unusually high tides overspread the Northeast and eastern portion of Middle Atlantic States. A fastest mile wind speed of 82 mi/h was measured at Newark, N.J., and a 110 mi/h gust at Concord, N.H., on 25th. Damage was more severe in New Jesey, eastern Pennsylvania, and interior and southeastern New York than in 1938 hurricane and almost as severe as that hurricane in New England.
1962 Mar. 6–9	Fla. to southern New England	33	200	Great Atlantic coast storm. Long fetch and persistence of gale to hurricane force winds in this extratropical cyclone raised the spring tides to near record levels. Waves 20 to 30 feet high.
1962 Oct. 12	North Pacific Coast to Cascades	13	150	Columbus Day "Big Blow." Winds over 120 mi/h on Washington and Oregon coast and 75 to 100 mi/h eastward to Cascades. Agricultural loss $60 million; 5 billion board feet of timber destroyed and another 5 billion damaged.

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* A cyclone, or low pressure circulation not of tropical origin. Extratropical cyclones normally are associated with frontal systems.

Chapter 7

Miscellaneous Phenomena

Floods, Droughts, and Fog
Wind, Relative Humidity, Sunshine, and Pressure

FLOODS

Floods are most frequent in the northern interior and the Northeast United States during the spring months. At this time of the year the combination of melting snow and heavy rainfall soaks the soil and fills streams to overflowing. In the Pacific States flooding occurs primarily during the rainy winter months. Flooding also occurs with some of the hurricanes or tropical storms that move inland. In recent years, hurricane Beulah (1967) caused flooding in Texas, hurricane Camille (1969) caused a disastrous flooding of the James River in Virginia, and hurricane Agnes (1972) caused extensive flooding from Virginia northward through Pennsylvania and into New York.

The average annual property damage caused by flooding in the conterminous United States during the 20-year period 1951 through 1970 was $450 million (adjusted to the 1970 price index). The average annual loss of life, nationally, was 83 during the 41-year period, 1925–71. Timely warnings issued by the River Forecast Centers of the National Weather Service are credited with saving many lives and millions of dollars worth of property annually.

DROUGHTS

A drought is a long period of abnormally dry weather affecting a relatively large area. The results of drought are lack of water for crops and other vegetation, and a severe shortage of water for human use. Crops suffer, use of water for other than essential needs is curtailed, rivers and streams are abnormally low or dry up, and ground water levels are well below normal. The severity of a drought is difficult to assess because of variations in normal precipitation pattern from one place to another. In general, drought severity depends on the amount of water deficiency, the duration, and to some extent the area affected.

The Palmer drought index has been in use since 1963 to show the current state of drought severity over the country. It is published in the *Weekly Weather & Crop Bulletin* in the form of a map showing the soil moisture situation. Isolines show the gradation of moisture from extremely wet to extremely dry. This weekly index is used by agricultural, industrial, and commercial interests.

Some of the outstanding droughts of the period 1894 to 1971 are listed below:

1894	Central Plains to Ohio Valley
1910	Great Plains and far Southwest
1917	Texas
1930–31	Central Mississippi Valley to the East Coast
1934–36	Rockies to Appalachians
1952–57	Mexican border to South Dakota and Central Mississippi Valley
1962–66	Great Lakes region to the Northeast

FOG

Fog, which consists of minute water particles, may be thought of as a cloud touching the ground surface. Fog differs from clouds only in location; clouds stay above the earth's surface, while fog touches the surface and restricts horizontal visibility to less than one kilometer (0.62 mile). Fog is formed by cooling the air to saturation. This may occur when warm air passes over cold water or land, when cold air passes over warm water (forming Arctic sea smoke), or when strong night-time radiation cools the lowest layers of the atmosphere to 100% relative humidity.

Heavy fog (visibility ¼ mile or less) occurs on from 80 to more than 100 days annually at the following locations: the northern part of the Pacific coast, along and off the California coast, in the Olympic and Cascade Ranges in the West, in the Appalachians, and along the New England coast (map 35). The Libby Islands of Maine, and Point Reyes, California, each have more than 1,500 hours of fog annually. Santa Catalina, off of California, has an annual average of 158 days with heavy fog.

Table 10.—Some outstanding floods, 1899-1972

Date	Location	Deaths	Property damage (millions of $)
1889 May	Conemaugh River near Johnstown, Pa. (Collapse of South Fork Dam)	2,200	$ —
1903 May-June	Lower Missouri, and Upper Mississippi Rivers in Kansas	100	40.0
1913 March	Ohio River and tributaries	467	147.0
1913 December	Rivers in Texas	177	9.0
1921 June	Arkansas River in Colorado	120	25.0
1921 September	Rivers in Texas	215	19.0
1927 Spring	Mississippi Valley	313	284.1
1927 November	Rivers in New England	88	45.6
1928 March	Santa Clara River, Calif. (Collapse of St. Francis Dam)	450	—
1935 May-June	Republican and Kansas Rivers	110	18.0
1936 March-April	Rivers in Eastern United States	107	270.0
1937 Jan.-Feb.	Ohio and Lower Mississippi River basins	137	417.7
1938 March	Streams in southern California	79	24.5
1939 July	Licking and Kentucky Rivers	78	1.7
1943 Apr.-June	Maumee, Wabash, Upper Mississippi, Missouri, White, and Arkansas River basins.	60	172.5
1947 May-July	Rivers in Middle West, in the lower Missouri, and in the Middle Mississippi River basins	29	235.0
1948 May-June	Columbia River Basin	35	101.7
1951 June-July	Kansas and Missouri	28	935.2
1952 April	Red River of the North, upper Mississippi, and Missouri River basins.	11	198.0
1955 August	Hurricane floods in northeastern U.S.	187	714.1
1955 December	West Coast	61	154.5
1957 Apr.-June	Streams in Texas, Arkansas, Kansas, Louisiana, Missouri, and Oklahoma.	18	105.0
1959 January	Ohio River basin	8	81.9
1963 March	Ohio River basin	26	97.6
1963 April	Kauai and Oahu Islands, Hawaii	—	2.3
1964 March	Ohio River basin	13	81.6
1964 June	Montana	31	54.3
1964 December	California and Oregon	40	415.8
1965 Mar.-May	Upper Mississippi, Missouri, and Red River of North basins.	16	181.3
1965 June	South Platte basin	16	415.1
1965 June	Sanderson, Texas (flash flood)	26	2.7
1967 August	Chena and Tanana Rivers (Fairbanks-Nanana, Alaska).	7	100.2
1967 September	Texas (hurricane Beulah)	—	98.2
1968 May 28-30	Northeastern New Jersey	7	133.0
1969 Jan.-Feb.	California (flooding and mudslides)	60	399.2
1969 Mar.-Apr.	Red River of North, Upper Mississippi and Missouri basins.	9	151.0
1969 July	Northern Ohio	30	87.9
1969 August	Upper James River, Virginia (hurricane Camille)	153	116.0
1970 January	Sacramento basin, California	18	38.1
1970 October	Puerto Rico	50	62.0
1971 August	New Jersey and southeastern Pennsylvania (hurricane Doria).	16	157.7
1972 February	Buffalo Creek, Logan Co., W. Va. (washout of Coal-Slag Dam).	118	10.0
1972 June	Black Hills, South Dakota	242	163.0
1972 June	North Carolina to New York, especially Pennsylvania, Maryland, Virginia and southwestern New York (hurricane Agnes).	113	3,000.0

The occurrence of heavy fog decreases to 10 days or less annually along the eastern slope of the Rockies, and to 2 days or less annually in the interior of the Southwest (in the California deserts, extreme southern Nevada, extreme western and southern Arizona, and from the southwest corner of New Mexico to the El Paso area of Texas). The Florida Keys report fewer than 5 days a year on which heavy fog occurs.

Fog is very infrequent in Hawaii, Puerto Rico, and the Virgin Islands. Heavy fog along the Alaskan coast ranges from 20 days a year on the southeast coast to more than 80 days a year over the outer Aleutian Islands. The west coast of Alaska along the Bering Sea experiences from 20 to more than 60 days of heavy fog annually. Fog days along the Arctic coast range from 60 to more than 70 days per year. The interior of Alaska experiences from 12 to more than 30 days of heavy fog annually.

WIND

The prevailing winds over an area are a strong influence on the type of climate the area will have. Onshore winds over coastal areas usually give such areas a milder and more moist climate than if the winds were from the interior of the continent.

The prevailing winds on the Pacific coast are from the northwest (maps 36, 37, and 38). Winds over the eastern two-thirds of the conterminous United States are from the northwest or north during January and February, and generally from south and southwest from May through August. In the Texas-Oklahoma area, however, southerly winds prevail from March through December. The easterly winds of the northeast trades prevail over the Florida peninsula except during December and January when north winds bring cooler weather.

The mean annual wind speed for the conterminous 48 states is 8 to 12 mi/h. In valleys and other sheltered locations, mean wind speeds are lower; on mountain ridges, in passes, and along coast lines they are considerably higher. Nearly every area has experienced wind speeds of more than 50 miles per hour (mi/h) and many areas speeds of over 100 mi/h. Such strong speeds can and usually are caused by thunderstorms, squall lines, frontal passages, hurricanes, or tornadoes. Downslope winds, such as chinook winds, and canyon winds often are very strong.

The highest wind speed ever measured by instruments on land was a 231 mi/h gust that occurred on April 12, 1934, at an elevation of 6,262 feet on Mount Washington, N.H. (5 minute speed 188 mi/h). A one-minute wind speed of 155 mi/h was measured at Hillsboro Light during the Florida hurricane of September 1947. The anemometer at Chetumal, Mexico, registered 175 mi/h before it was destroyed on September 28, 1955, during hurricane Janet. During the 1935 Labor Day hurricane, wind speeds on the Florida Keys were estimated at 200 to 250 mi/h. An aircraft flying in typhoon Ida measured a wind speed of 225 knots (260 mi/h) on September 23, 1958; the measurement was made at 17.3N, 135.7E or about 750 miles east of the island of Luzon in the Philippines. It is estimated that the maximum wind speeds that can be reached in tornadoes are in excess of 400 mi/h. Wind speeds of 200 mi/h are fairly common at high altitudes in the free atmosphere.

Mean monthly wind speeds for Alaska are:

Area	*Speed* (*mi/h*)
South central coast	4 to 10
Southeast	9 to 15
Aleutian Islands	14 to 21+
West coast	10 to 15
Arctic coast	11 to 16+
Interior valleys	3 to 10

In Alaska, extremes of 60 to 70+ mi/h occur almost every month of the year in exposed parts of the southeast, south, and southwest coasts and over the coastal islands. Wind speeds occasionally reach 90 mi/h or more in the Aleutians during the winter. In the Bristol Bay and west-central areas of Alaska, winds with speeds of 60 to 70 mi/h may blow for 2 or 3 consecutive days. Strong, persistent winds, often reaching 50 to 60 mi/h and occasionally exceeding 70 mi/h, tend to blow parallel to the Arctic coastline.

Hawaii is under the influence of the northeast trade winds that blow with a fairly constant average speed of 12 mi/h. The topography of the islands and the land and sea breezes deflect these easterly winds considerably. Although high wind speeds are unusual, downslope and canyon winds may blow with speeds as high as 40 mi/h a few times a year; once every 5 to 10 years these winds reach speeds of from 60 to 100 mi/h. Brisk winds accompany the few cold fronts and extratropical cyclones (Kona storms) that move across the islands each year.

The outstanding feature of wind in Puerto Rico and the Virgin Islands is the steadiness with which the trades blow across the island from the east. The speed of these easterlies is from 3 to 9 mi/h between 2:00 a.m. and 7:00 a.m. and increases to 14 to 19 mi/h by noon or early afternoon, after which the speed gradually decreases again. Land and sea breezes have a modifying effect on wind speeds (and temperatures) depending on the orientation of the shoreline.

RELATIVE HUMIDITY

Relative humidity is a percentage value that expresses the ratio between the actual amount of water vapor in the air and the amount of water vapor the air could hold at the given temperature. The higher the temperature the more water vapor the air can hold. If the air is holding one half as much water vapor as it could hold, the relative humidity is 50 percent. If the air is cooled to saturation (100% relative humidity), fog or dew can form, depending on wind conditions and other factors. Conversely, early morning fog is dissipated by rising temperatures. The effect here is that the relative humidity is 100% in fog, but as temperature increases the capacity of the air to hold more water vapor also increases, so the relative humidity decreases to less than 100% and the fog evaporates.

An increase of 20°F usually doubles the capacity of air to hold water vapor; consequently when air temperature increases 20°F an existing 100% relative humidity will decrease to 50%. In general relative humidities are lower during the afternoon when the air temperature reaches its daily maximum, and higher in the early morning when the minimum temperature for the day occurs (map 39).

A hot, humid day is more oppressive than a hot, dry day because the high relative humidity reduces the rate at which perspiration evaporates from the body. Evaporation of perspiration is the cooling mechanism that permits the human body to tolerate relatively high temperatures. Relative humidity and other measures of atmospheric moisture used in computing the effective temperature are discused in chapter 3. Effective temperature and other measures of comfort are used for determining the best temperature and moisture conditions for inside of buildings. Adding moisture to air made dry by indoor heating not only reduces the drying effect on the nasal system, but also makes the building comfortable at a lower temperature by reducing evaporative cooling of the body. Thus increased comfort is achieved with a saving of fuel. The preferred indoor relative humidity range is 40 to 60%.

Relative humidities are highest in coastal areas where winds blowing inland from water surfaces carry much moisture (maps 40 thru 46). Relative humidities are lower at inland stations and lowest in the deserts and semi-arid interior of the Far Southwest. For example, during January, Tampa, Florida, has 6:00 a.m. and 3:00 p.m. relative humidities of 88% and 55% while for the same times Yuma, Arizona, has relative humidities of 57% and 30%. July values are about 85% and 60% for Tampa and 50% and 22% for Yuma.

The rate of evaporation from specially designed pans shows the general humidity or dryness of the atmosphere. In the deserts and semi-arid areas of California, Arizona, New Mexico, and Texas, pan evaporation ranges from 100 to more than 120 inches of water annually (map 47). In the Pacific Northwest, the northern Rockies, the Great Lakes region, and the Northeast, annual pan evaporation is less than 40 inches per year.

Relative humidities in coastal areas of Alaska during summer range from 80% to 90% in midafternoon and from 90% to near 100% at night. Winter values for the coastal areas range from 80% to 90% in the south and from 65% to 75% along the Arctic coast, where humidity is lower because the sea is frozen over. Summer relative humidities in the interior range from 85% to 90% during the hours of darkness and decrease to 50% by mid-afternoon; in winter the relative humidity remains between 68% and 75% most of the time.

Hawaii reports relative humidities of 65% to 75% in the early afternoon and 80% to 90% or more at night and early in the morning on the windward sides of the islands; on the leeward sides relative humidities average 10% to 15% lower. In heavy rain areas, particularly on the windward side of the mountains between the 2,000- to 5,000-ft levels, humidity is generally higher. Above 6,000 feet, relative humidities are generally less than 40%.

In Puerto Rico and the Virgin Islands, relative humidities range between 80% and 90% during the night and early morning, and 60% to 75% by noon or early afternoon.

SUNSHINE

Possible sunshine, the total number of hours of sunlight a location can receive annually in the absence of clouds, depends only on latitude. At the equator, the earth can receive 4,420 hours of sunlight annually; at 25°N, the latitude of the Florida Keys, 4,449 hours; at 49°N, at the western U.S.-Canadian border, 4,486 hours; and at 90°N, the North Pole, 4,580 hours. In the conterminous United States, the longest day—sunrise to sunset—is 16 hours and 13 minutes at 49°N and occurs about June 21; the shortest day, about December 21, occurs at the same latitude and is 8 hours and 13 minutes. At 25°N the longest and shortest days are, respectively, 13 hours and 42 minutes and 10 hours and 38 minutes.

Fewer hours of daylight and general cloudiness make for less sunshine in winter than in summer. Coastal areas generally have more cloudiness than interior areas, mountainous areas more than plains areas, and desert areas the least cloudiness of all.

During November, December, and January, the monthly total hours of sunshine are the least: 60 to 100 hours, or 20% to 40% of the possible, in the Pacific Northwest; and 80 to 100 hours, or 30% to 40% of the possible, in the Great Lakes region, northeastern Canadian border districts, and most of the Appalachians (maps 48 and 49.) The sunniest section during winter is the extreme southeastern California and extreme southern and western Arizona area where the monthly totals exceed 240 hours, or 80% of the possible.

In the summer, most of the conterminous United States receives over 300 hours of sunshine a month, about 60% to over 90% of the possible (maps 48 and 50). The lowest summer (June-August) mean monthly totals are about 220 to 240 hours, 50% to 55% of the possible, on the Washington coast; and about 240 to 260 hours, 50% to 60% of the possible, in sections of the Appalachians. The greatest monthly hours of sunshine, usually more than 400 hours, or more than 90% of the possible, occur in the San Joaquin and lower Sacramento Valleys of California during June, July, and August, and in extreme southeast California and western Arizona during May and June.

The least mean total sunshine occurs along the Washington and Oregon coasts and extends over the Cascades; here there are 1,800 to 2,200 total hours of sunshine annually, or slightly less than 50% of the possible total sunshine. The Great Lakes region receives 2,000 to 2,400 hours annually, or 50% to 55% of the possible total. The interior areas of the Far Southwest receive the greatest annual hours of sunshine—an average of over 3,500 hours, or 85% to 90% of the possible total. The San Joaquin Valley and the deserts of southeastern California and western Arizona receive the most. Yuma records an annual total of 4,077 hours, or 91% of the total possible.

At Anchorage, Alaska, the longest period of daylight in any 24-hour period is 19 hours 2[illegible] minutes, the shortest period is 5 hours 26 minutes. At Point Barrow there is continuous daylight from about 1:00 a.m. on May 10 to near midnight on August 2, a period of 85 days. In winter, Point Barrow is in continuous darkness from shortly after noon on November 18 to shortly before noon on January 24, a period of 67 days. Cloudiness is heavy over Alaska, ranging from 80% to 95% in coastal areas to 60% to 75% over inland areas.

The effects of the extreme variability of daylight hours and heavy cloudiness over Alaska are shown in the following table:

In Hawaii, cloudiness is greater on the windward sides of the islands than on the leeward sides, with an average of 4- to 6-tenths of the sky covered on the windward sides and about 2-tenths on the lee sides. At the 2,000 to 5,000-foot levels on the windward sides of mountains, cloudiness averages 6 to 8 tenths. Skies above the 8,000-foot level are normally clear except for a few hours in the afternoon. The length of daylight in Honolulu varies from about 13 hours 26 minutes in late June to 10 hours 50 minutes in late December. Sunshine ranges from 76% of the total possible in July to 63% of the total possible in February; the annual sunshine total is 3,059 hours, or 69% of the total possible. At Hilo, where there is much more rainfall than at Honolulu, sunshine ranges from 41% of the total possible in July to 29% in May; the annual sunshine total is 1,686 hours, or 38% of the total possible.

At San Juan, Puerto Rico, the length of daylight ranges from 13 hours 15 minutes about June 21 to 11 hours 1 minute about December 21. The sunshine recorded there ranges from 72% of the total possible in March to 59% in December; total annual sunshine is 2,792 hours, or 63% of possible. The areas of heavy rainfall in Puerto Rico experience less sunshine than San Juan and the southern coastal plain slightly more than the rest of the island. (Also see maps 53 thru 60).

ATMOSPHERIC PRESSURE

Over the conterminous United States the average sea level pressure is lower in summer than in winter. (See maps 61, 62, and 63). Cyclones predominate during the warmer part of the year and anticyclones during the colder part. Exceptions are the Southwest border area where pressure is generally low throughout the year and the northern lake region where low pressure predominates during November. Pressure tends to be high off the northwest coast from May to October because of the warm season expansion of the semi-permanent Pacific high cell. Another high pressure anomaly is found over southern Idaho, where higher than normal pressure exists from November to February. The Bermuda high pressure cell brings high pressure

Station	December		June		Year	
	*	**	*	**	*	**
Juneau	51	18	251	35	1,680	30
Anchorage	49	29	288	51	1,992	45
Nome	42	30	297	48	1,884	41
Fairbanks	36	29	334	53	2,105	44

* Actual hours of sunshine
** Percentage of total possible sunshine

over the Southeast from late September through December.

The largest variations in sea level pressure occur during the colder part of the year with the passage of cold fronts and their accompanying low pressure centers, particularly over the northern tier of States east of the Rockies, and in the Pacific Northwest. The smallest variations in pressure occur in the border area of the Far Southwest.

Pressure over Alaska is generally rather low, except from November to May in the extreme north and from June to August in the extreme southeast. The greatest contrasts occur in midwinter when the Aleutian Low is most intense. Average pressure during February ranges from 999 millibars (29.50 in.) on the outer Aleutian Islands to 1,020 millibars (30.12 in.) on the Arctic coast.

Sea level pressure over Hawaii is rather uniform ranging from 1,015 millibars (29.97 in.) in September to 1,018 millibars (30.06 in.) during April, May, and June. Puerto Rico and the Virgin Islands also are in an area of rather uniform average sea level pressures. Pressure here ranges from 1,013 millibars (29.91 in.) during October and November to 1,017 millibars (30.03 in.) during January and February, and also during July.

The following are absolute extremes of sea level pressure for the United States and for the world.

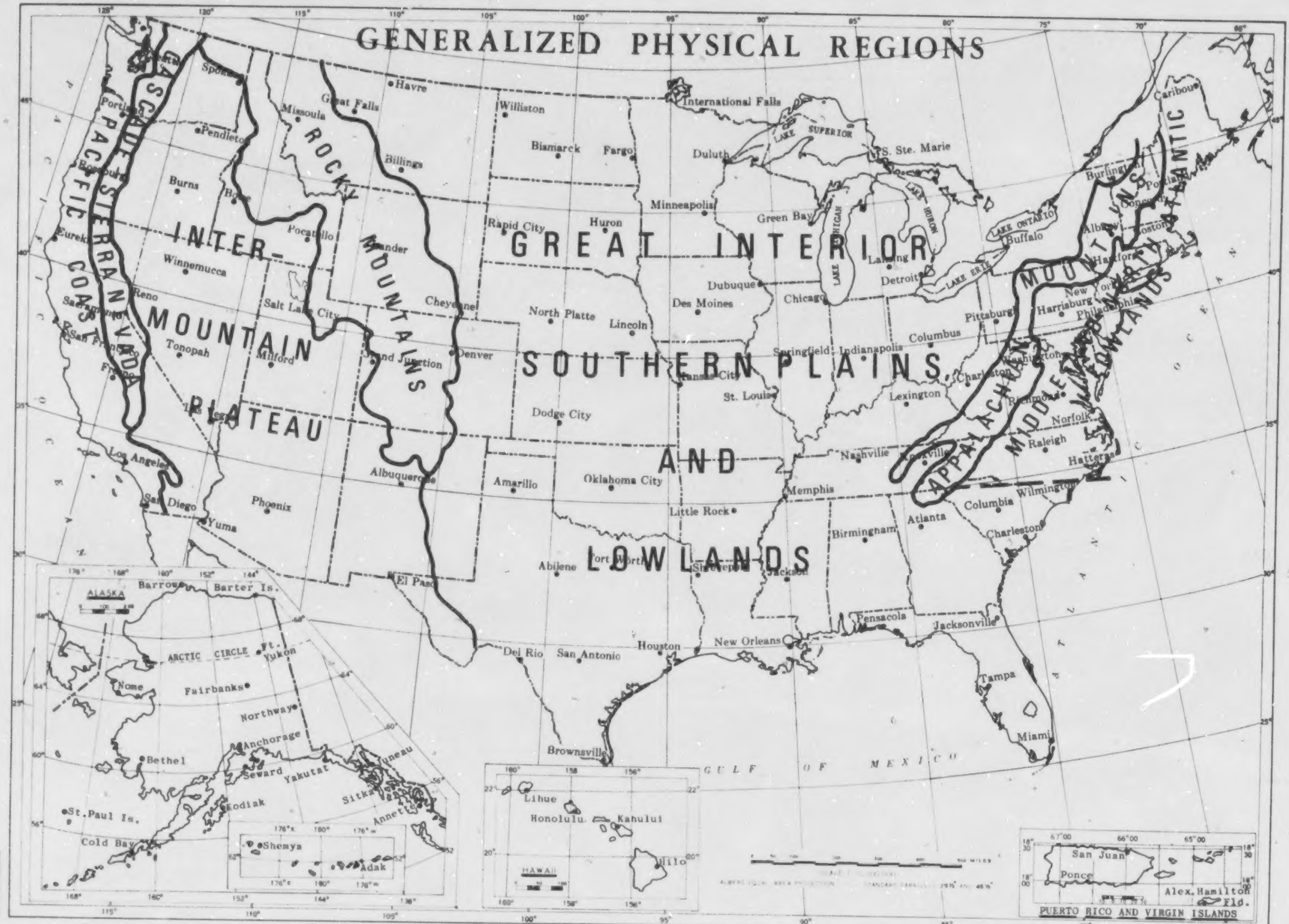
Location	Pressure		Date	Remarks
	mb*	in		
Helena, Mont.	1,063.3	31.40	Jan. 9, 1962	U. S. record high
Agata, Siberia	1,083.8	32.01	Dec. 3, 1968	World record high
Lower Matecumbe Key, Fla.	892.3	26.35	Sept. 2, 1935	U.S. record low—hurricane
750 mi. east of Luzon, P.I.	877.0	25.90	Sept. 24, 1958	World record low—typhoon Ida.

* Millibars

Part III: Maps

Numbers	Description
1	Generalized Physical Regions
2	Normal Daily Maximum Temperature, January
3	Normal Daily Minimum Temperature, January
4	Mean Monthly Number of Days Minimum Temperature 32°F and Below (July-June)
5	Mean Annual Number of Days Minimum Temperature 32°F and Below
6	Normal Daily Maximum Temperature, July
7	Normal Daily Minimum Temperature, July
8	Mean Monthly Number of Days Maximum Temperature 90°F and Above, Except 70°F and Above in Alaska
9	Mean Annual Number of Days Maximum Temperature 90°F and Above, Except 70°F and Above in Alaska
10	Normal Daily Maximum, Average, Minimum, and Extreme Temperature (°F) by Months, Western United States
11	Normal Daily Maximum, Average, Minimum, and Extreme Temperature (°F) by Months, Eastern United States
12	Mean Daily Temperature Range (°F), January
13	Mean Daily Temperature Range (°F), July
14	Mean Annual Temperature Range (°F)
15	Mean Date of Last 32°F Temperature in Spring
16	Mean Date of First 32°F Temperature in Autumn
17	Mean Length of Freeze-Free Period (Days)
18	Mean Annual Total Heating Degree Days (Base 65°F)
19	Mean Annual Total Cooling Degree Days (Base 65°F)
20	Mean Annual Total Precipitation (Inches)
21	Mean Annual Number of Days With 0.01 Inch or more of Precipitation
22	Normal Monthly Total Precipitation (Inches), Western United States
23	Normal Monthly Total Precipitation (Inches), Eastern United States
24	Mean Monthly Number of Days With 0.01 Inch or more Precipitation
25	Mean Annual Total Snowfall (Inches)
26	Mean Monthly Snowfall (Inches) for Selected Stations Western United States
27	Mean Monthly Snowfall (Inches) for Selected Stations Eastern United States
28	Mean Annual Number of Days with 1 Inch or more Snowfall
29	Mean Annual Number of Days with Ice Pellets
30	Mean Annual Number of Days with Glaze (Freezing Rain)
31	Mean Annual Number of Days with Thunderstorms
32	Mean Annual Number of Days with Hail
33	Mean Monthly Number of Tornadoes by States
34	Major Weather Disasters
35	Mean Annual Number of Days with Heavy Fog
36	Mean Surface Wind Roses, January
37	Mean Surface Wind Roses, July
38	Mean Surface Wind Roses, Annual
39	Mean Hourly Relative Humidity (%) January (Dashed Lines) and July (Solid Lines)
40	Mean Daily Highest Relative Humidity (%), January
41	Mean Daily Lowest Relative Humidity (%), January
42	Mean Daily Relative Humidity (%), January
43	Mean Daily Highest Relative Humidity (%), July
44	Mean Daily Lowest Relative Humidity (%), July
45	Mean Daily Relative Humidity (%), July
46	Mean Daily Relative Humidity (%), Annual
47	Mean Annual Pan Evaporation (In Inches)

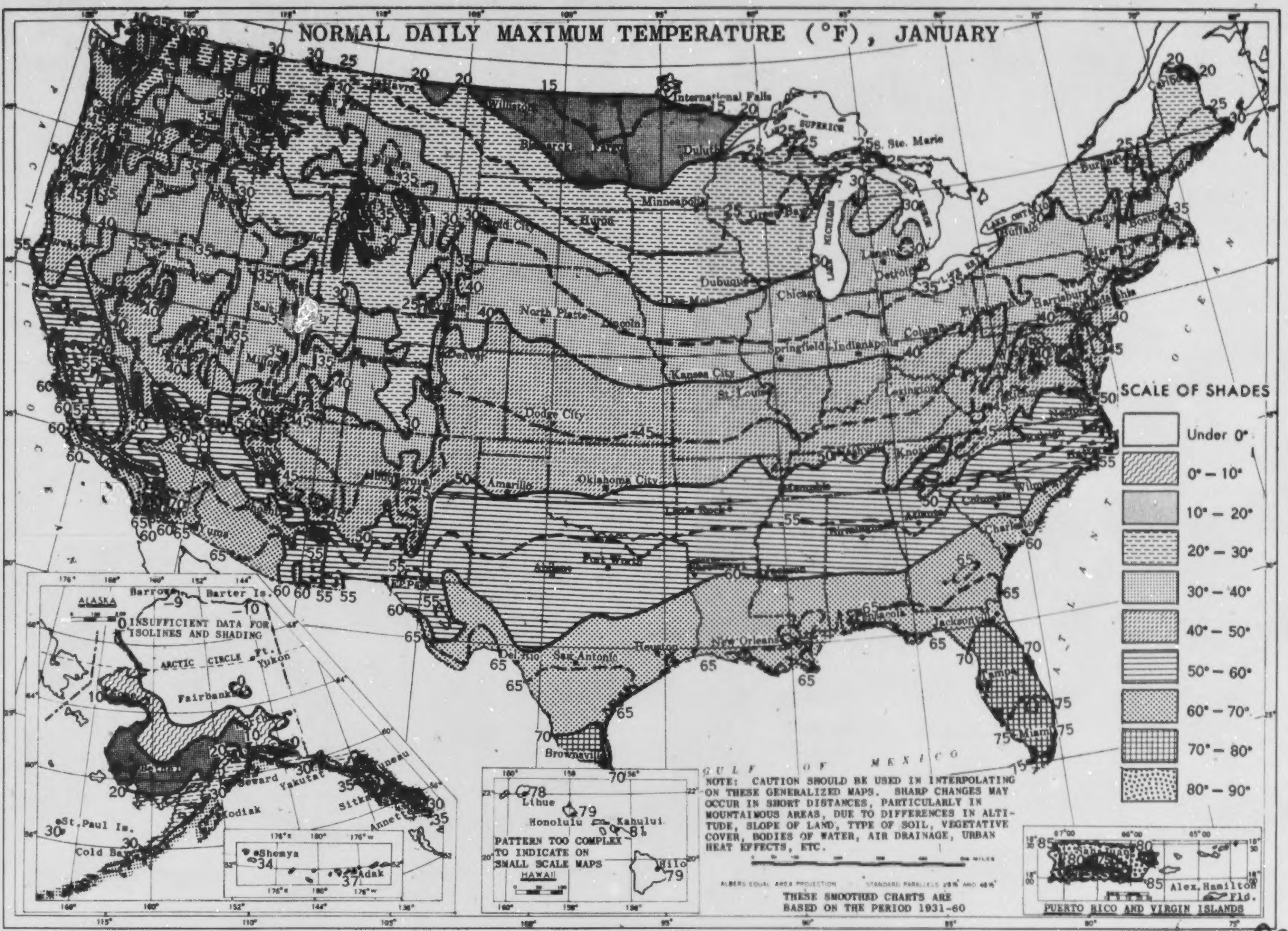
48 Mean Monthly Total Hours of Sunshine
49 Mean Percentage of Possible Sunshine, January
50 Mean Percentage of Possible Sunshine, July
51 Mean Total Hours of Sunshine, Annual
52 Mean Percentage of Possible Sunshine, Annual
53 Mean Daily Solar Radiation (Langleys), January
54 Mean Daily Solar Radiation (Langleys), July
55 Mean Daily Solar Radiation (Langleys), Annual
56 Mean Daily Sky Cover (In Tenths), Sunrise to Sunset, by Months
57 Mean Daily Sky Cover, Sunrise to Sunset (In Tenths), January
58 Mean Daily Sky Cover, Sunrise to Sunset (In Tenths), July
59 Mean Daily Sky Cover, Sunrise to Sunset (In Tenths), Annual
60 Mean Annual Number of Clear Days, Sunrise to Sunset
61 Normal Sea Level Pressure, January
62 Normal Sea Level Pressure, July
63 Normal Sea Level Pressure, Annual



GENERALIZED PHYSICAL REGIONS

PACIFIC COAST
CASCADE
SIERRA NEVADA
INTER-MOUNTAIN PLATEAU
ROCKY MOUNTAINS
GREAT INTERIOR SOUTHERN PLAINS, AND LOWLANDS
APPALACHIAN MOUNTAINS
MIDDLE ATLANTIC LOWLANDS
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Seattle
Spokane
Portland
Pendleton
Roseburg
Eureka
Burns
Boise
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Missoula
Great Falls
Havre
Billings
Pocatello
Salt Lake City
Milford
Lander
Cheyenne
Grand Junction
Denver
Albuquerque
El Paso
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Des Moines
Dubuque
Kansas City
St. Louis
Little Rock
Shreveport
Jackson
Memphis
Nashville
Knoxville
New Orleans
S. Ste. Marie
Green Bay
Lansing
Detroit
Chicago
Springfield
Indianapolis
Columbus
Lexington
Pittsburgh
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Pensacola
Jacksonville
Tampa
Miami
Buffalo
Harrisburg
Philadelphia
New York
Hartford
Albany
Boston
Concord
Portland
Burlington
Caribou
ALASKA
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks
Northway
Anchorage
Bethel
Seward
Yakutat
Juneau
Sitka
Kodiak
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

Map 2


SCALE OF SHADES
Under 0°
0° – 10°
10° – 20°
20° – 30°
30° – 40°
40° – 50°
50° – 60°
60° – 70°
70° – 80°
80° – 90°
ALASKA
INSUFFICIENT DATA FOR ISOLINES AND SHADING
ARCTIC CIRCLE
Barrow
Barter Is.
Ft. Yukon
Fairbanks
Seward
Yakutat
Kodiak
Sitka
Juneau
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAPS
Lihue
Honolulu
Kahului
Hilo
PUERTO RICO AND VIRGIN ISLANDS
Alex. Hamilton Fld.
GULF OF MEXICO
International Falls
Williston
Bismarck
Fargo
Duluth
Minneapolis
Huron
Green Bay
S. Ste. Marie
Lansing
Detroit
Chicago
Dubuque
Des Moines
North Platte
Lincoln
Springfield
Indianapolis
Columbus
Kansas City
St. Louis
Denver
Dodge City
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Lexington
Birmingham
Atlanta
Columbia
Wilmington
Charleston
Jacksonville
Tampa
Miami
Pensacola
New Orleans
Jackson
Houston
San Antonio
Del Rio
Brownsville
Fort Worth
Abilene
El Paso
Yuma
Buffalo
Albany
Boston
Caribou
Burlington
Harrisburg
Philadelphia
Norfolk
Raleigh
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
PACIFIC OCEAN
ATLANTIC OCEAN

NORMAL DAILY MAXIMUM TEMPERATURE (°F), JANUARY

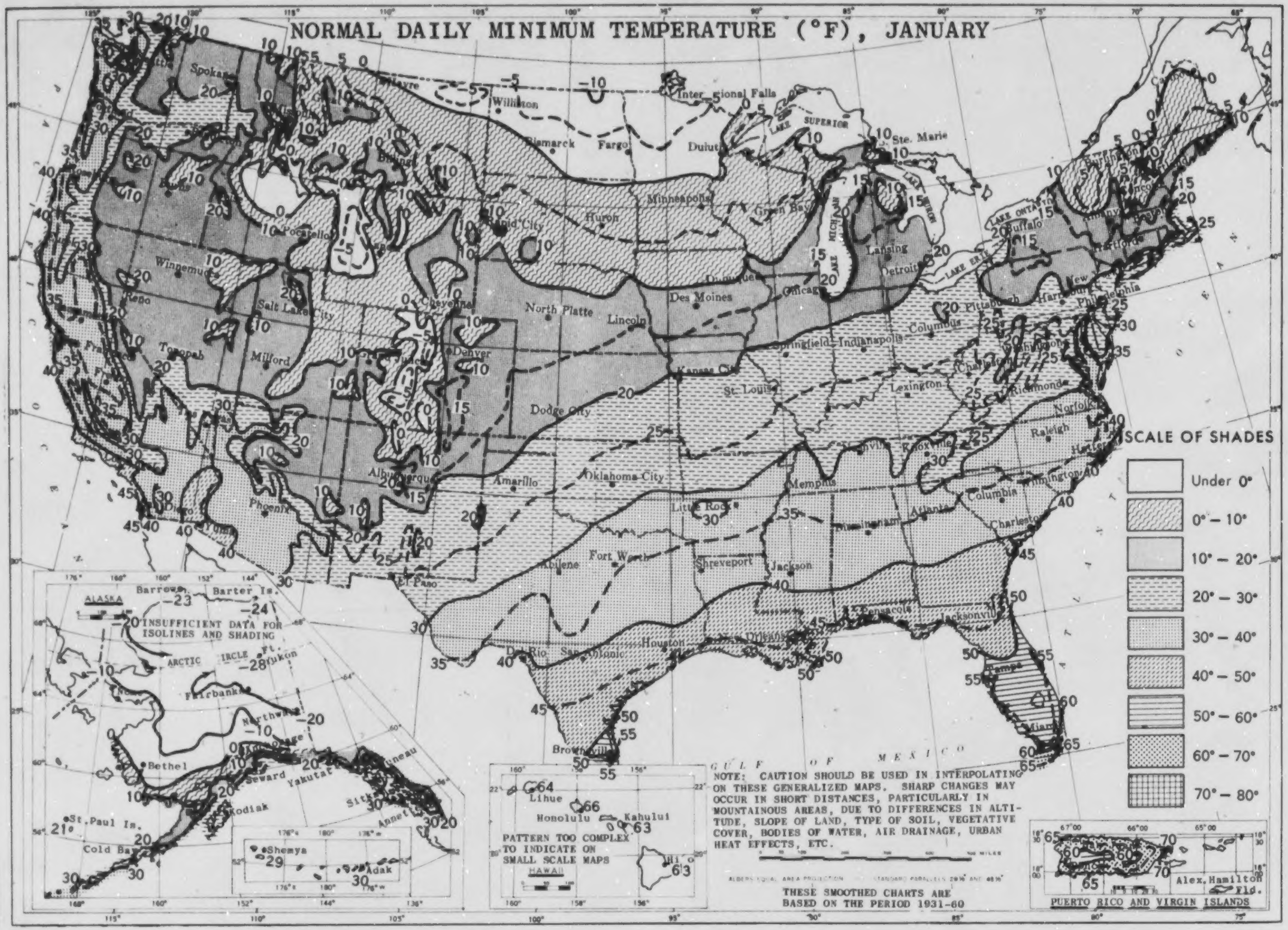
NOTE: CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

ALBERS EQUAL AREA PROJECTION   STANDARD PARALLELS 29½° AND 45½°

THESE SMOOTHED CHARTS ARE BASED ON THE PERIOD 1931-60

Map 3

NORMAL DAILY MINIMUM TEMPERATURE (°F), JANUARY

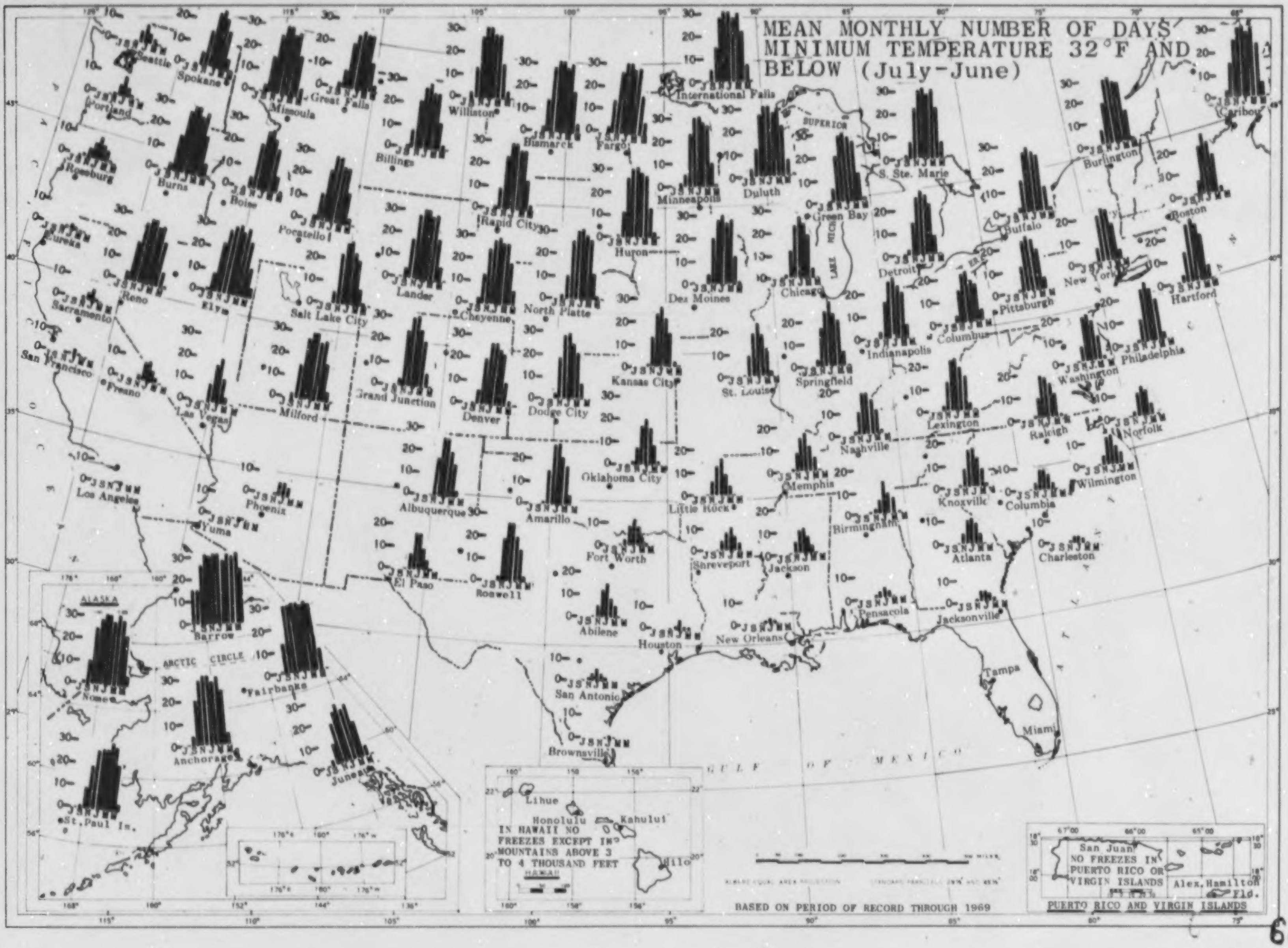


SCALE OF SHADES
Under 0°
0° – 10°
10° – 20°
20° – 30°
30° – 40°
40° – 50°
50° – 60°
60° – 70°
70° – 80°
Spokane
Williston
Bismarck
Fargo
Duluth
International Falls
LAKE SUPERIOR
Ste. Marie
Minneapolis
Green Bay
Huron
Rapid City
Pocatello
Winnemucca
Reno
Salt Lake City
Tonopah
Milford
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
LAKE MICHIGAN
Lansing
Detroit
LAKE HURON
LAKE ERIE
LAKE ONTARIO
Buffalo
Burlington
Concord
Albany
Hartford
Boston
New York
Harrisburg
Philadelphia
Pittsburgh
Columbus
Indianapolis
Springfield
Washington
Charleston
Lexington
Richmond
Norfolk
Raleigh
Hatteras
Denver
Grand Junction
Kansas City
St. Louis
Dodge City
Amarillo
Oklahoma City
Albuquerque
Phoenix
San Diego
Fresno
El Paso
Abilene
Fort Worth
Shreveport
Little Rock
Memphis
Nashville
Knoxville
Birmingham
Atlanta
Columbia
Wilmington
Charleston
Jackson
Pensacola
Jacksonville
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Tampa
Miami
GULF OF MEXICO
P A C I F I C O C E A N
A T L A N T I C O C E A N
ALASKA
Barrow
Barter Is.
INSUFFICIENT DATA FOR ISOLINES AND SHADING
ARCTIC CIRCLE
Ft. Yukon
Fairbanks
Northway
Bethel
Anchorage
Seward
Yakutat
Juneau
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAPS
PUERTO RICO AND VIRGIN ISLANDS
Alex. Hamilton Fld.
ALBERS EQUAL AREA PROJECTION STANDARD PARALLELS 29½° AND 45½°
-23
-24
-28
-20
-10
0
10
20
21
29
30
64
66
63
65
70
60
-10
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
65

NOTE: CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

THESE SMOOTHED CHARTS ARE BASED ON THE PERIOD 1931-60

Map 4



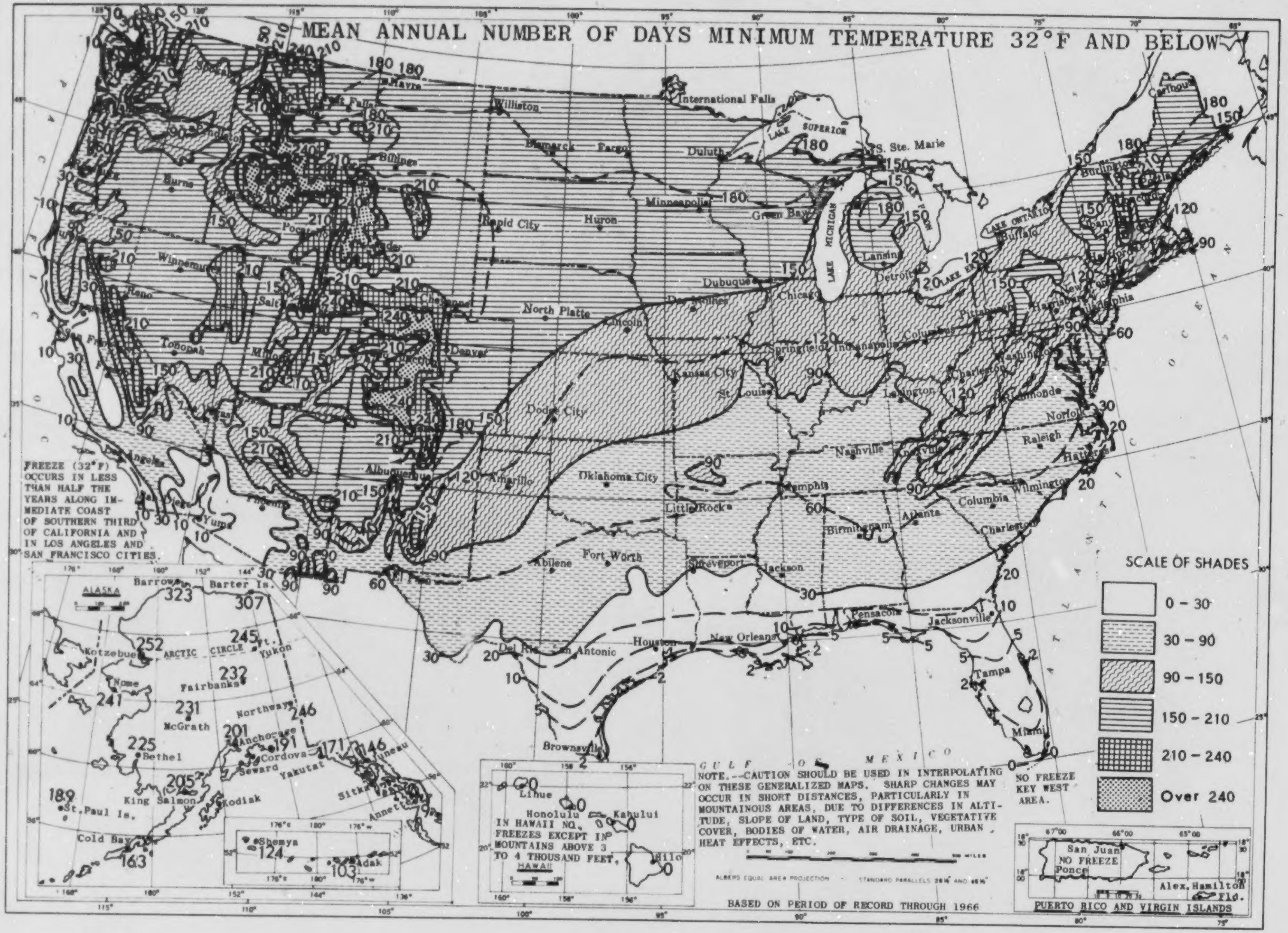
MEAN MONTHLY NUMBER OF DAYS MINIMUM TEMPERATURE 32°F AND BELOW (July-June)

BASED ON PERIOD OF RECORD THROUGH 1969

IN HAWAII NO FREEZES EXCEPT IN MOUNTAINS ABOVE 3 TO 4 THOUSAND FEET

NO FREEZES IN PUERTO RICO OR VIRGIN ISLANDS

J S N J M M
0
10
20
30
Seattle
Spokane
Portland
Roseburg
Missoula
Great Falls
Williston
International Falls
Burns
Boise
Billings
Bismarck
Fargo
Minneapolis
Duluth
SUPERIOR
S. Ste. Marie
Burlington
Caribou
Eureka
Reno
Ely
Pocatello
Rapid City
Huron
Green Bay
LAKE MICHIGAN
Buffalo
Boston
Sacramento
Salt Lake City
Lander
Cheyenne
North Platte
Des Moines
Chicago
Detroit
Pittsburgh
New York
Hartford
San Francisco
Fresno
Las Vegas
Milford
Grand Junction
Denver
Dodge City
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Washington
Philadelphia
Los Angeles
Phoenix
Yuma
Albuquerque
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Lexington
Raleigh
Norfolk
Wilmington
Knoxville
Columbia
Birmingham
Atlanta
Charleston
El Paso
Roswell
Fort Worth
Shreveport
Jackson
Abilene
Houston
New Orleans
Pensacola
Jacksonville
San Antonio
Brownsville
Tampa
Miami
GULF OF MEXICO
ALASKA
Barrow
ARCTIC CIRCLE
Nome
Fairbanks
Anchorage
Juneau
St. Paul Is.
HAWAII
Lihue
Honolulu
Kahului
Hilo
PUERTO RICO AND VIRGIN ISLANDS
San Juan
Alex. Hamilton Fld.



MEAN ANNUAL NUMBER OF DAYS MINIMUM TEMPERATURE 32°F AND BELOW

Havre
Williston
International Falls
Lake Superior
Duluth
S. Ste. Marie
Caribou
Bismarck
Fargo
Burns
Billings
Rapid City
Huron
Minneapolis
Green Bay
Lake Michigan
Lake Huron
Burlington
Lake Ontario
Buffalo
Albany
Winnemucca
Pocatello
Lander
Dubuque
Lansing
Detroit
Lake Erie
Reno
Salt Lake
Cheyenne
North Platte
Des Moines
Chicago
Pittsburgh
Harrisburg
New York
Philadelphia
Tonopah
Milford
Denver
Lincoln
Springfield
Indianapolis
Columbus
Washington
Kansas City
St. Louis
Charleston
San Francisco
Fresno
Las Vegas
Dodge City
Lexington
Richmond
Norfolk
Nashville
Knoxville
Raleigh
Hatteras
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Wilmington
San Diego
Phoenix
Yuma
Little Rock
Birmingham
Atlanta
Columbia
Charleston
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
ALASKA
Barrow 323
Barter Is. 307
Kotzebue 252
ARCTIC CIRCLE
Ft. Yukon 245
Fairbanks 232
Nome 241
McGrath 231
Northway 246
Anchorage 201
Bethel 225
Cordova 191
Yakutat 171
Juneau 146
Seward
King Salmon 205
Kodiak
Sitka
Annette
St. Paul Is. 189
Cold Bay 163
Shemya 124
Adak 103
HAWAII
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.

FREEZE (32°F) OCCURS IN LESS THAN HALF THE YEARS ALONG IMMEDIATE COAST OF SOUTHERN THIRD OF CALIFORNIA AND IN LOS ANGELES AND SAN FRANCISCO CITIES.

IN HAWAII NO FREEZES EXCEPT IN MOUNTAINS ABOVE 3 TO 4 THOUSAND FEET.

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

NO FREEZE KEY WEST AREA.

San Juan NO FREEZE

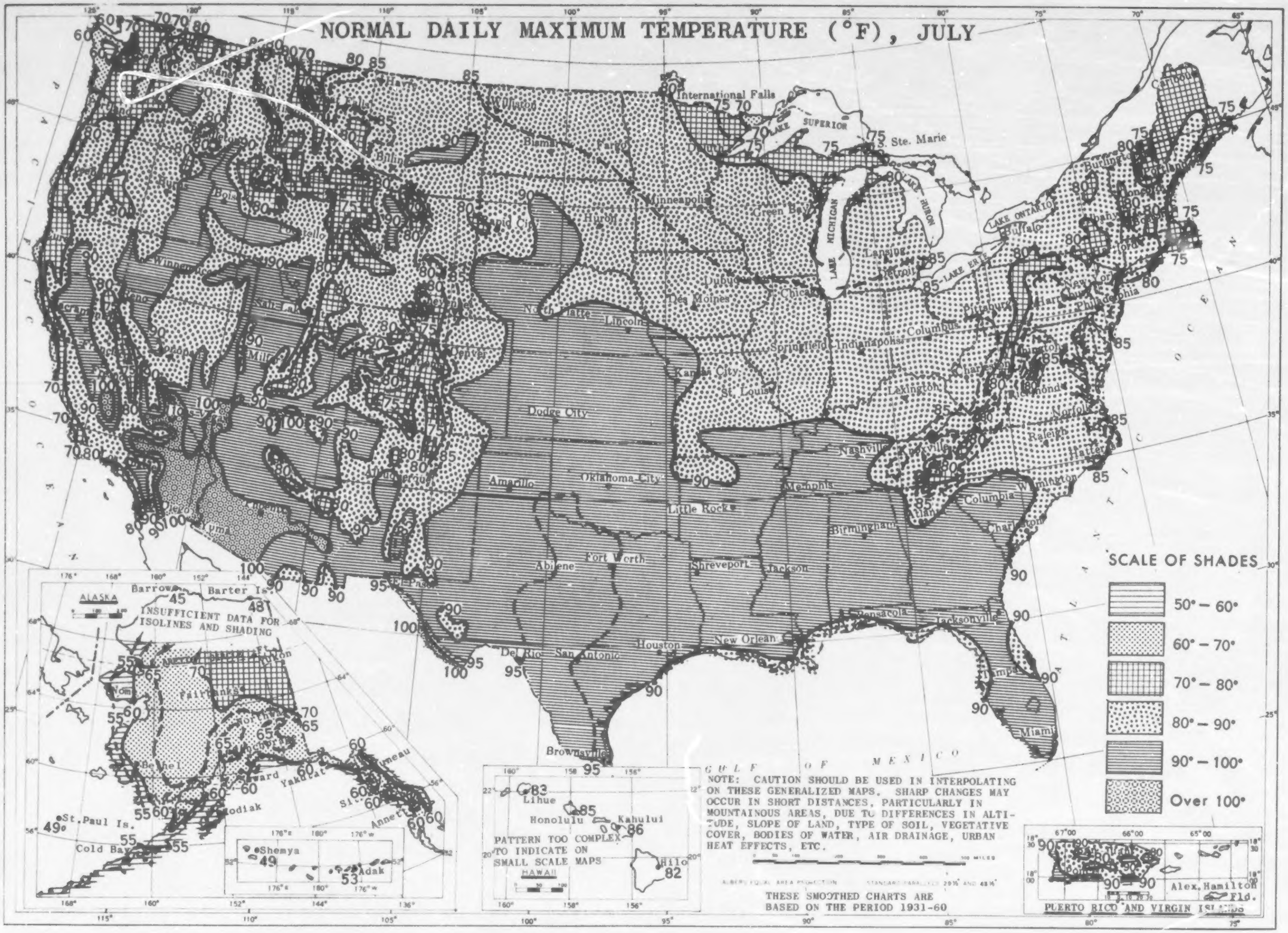
SCALE OF SHADES

- ☐ 0 - 30
- ▨ 30 - 90
- ▨ 90 - 150
- ▤ 150 - 210
- ▦ 210 - 240
- ▩ Over 240

ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°

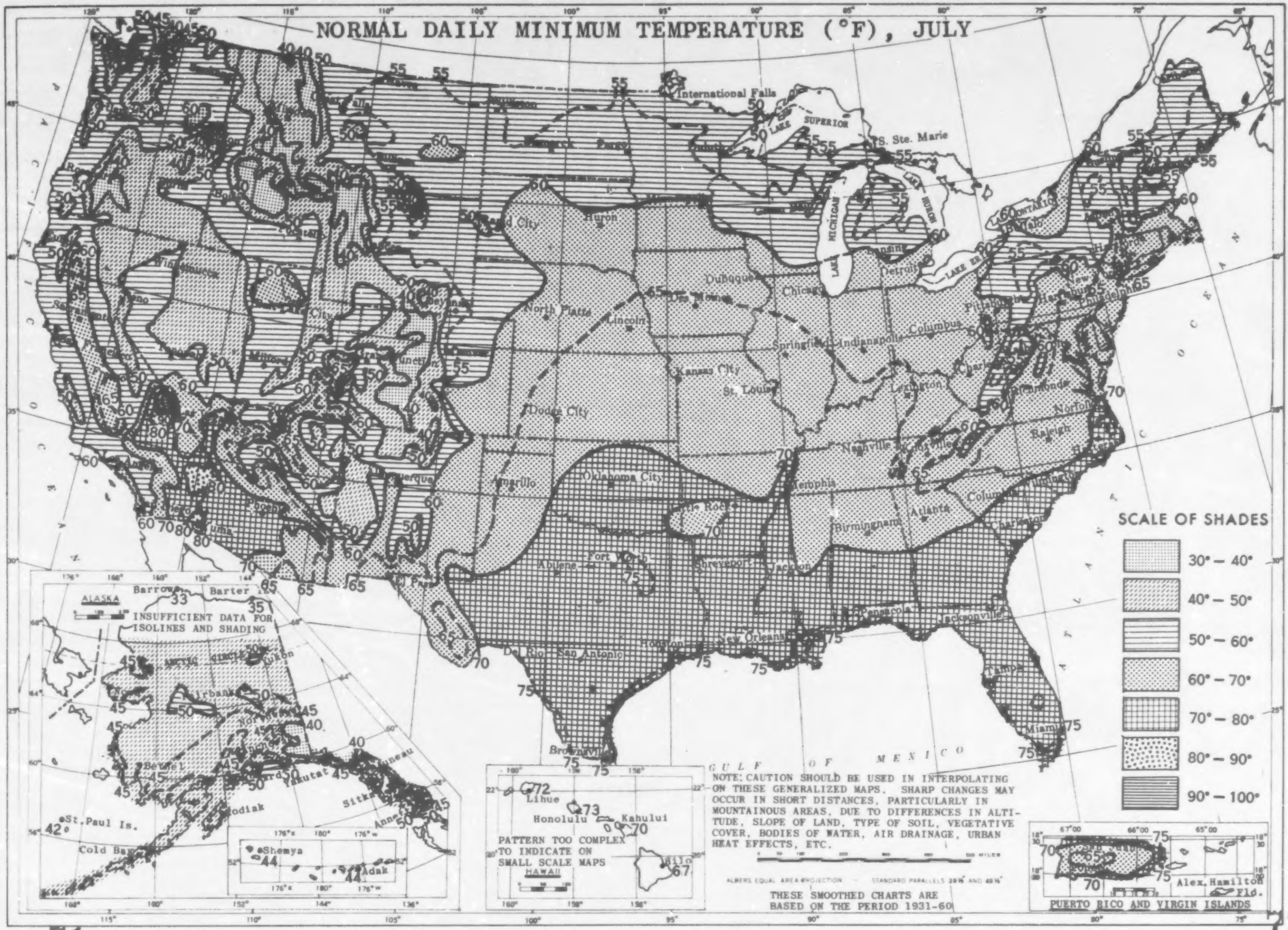
BASED ON PERIOD OF RECORD THROUGH 1966

PUERTO RICO AND VIRGIN ISLANDS


NORMAL DAILY MAXIMUM TEMPERATURE (°F), JULY
SCALE OF SHADES
50° – 60°
60° – 70°
70° – 80°
80° – 90°
90° – 100°
Over 100°
ALASKA
INSUFFICIENT DATA FOR ISOLINES AND SHADING
Barrow 45
Barter Is. 48
Fairbanks
Bethel
Yakutat
Juneau
Kodiak
Annette
St. Paul Is. 49
Cold Bay
Shemya 49
Adak 53
HAWAII
Lihue 83
Honolulu 85
Kahului 86
Hilo 82
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAPS
PUERTO RICO AND VIRGIN ISLANDS
Alex. Hamilton Fld.
P A C I F I C   O C E A N
A T L A N T I C   O C E A N
G U L F   O F   M E X I C O
International Falls
Sault Ste. Marie
Minneapolis
Green Bay
Chicago
Des Moines
Lincoln
North Platte
Rapid City
Huron
Fargo
Bismarck
Williston
Billings
Pocatello
Boise
Winnemucca
Reno
Salt Lake City
Cheyenne
Denver
Dodge City
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Lansing
Detroit
Buffalo
Pittsburgh
Burlington
Concord
Boston
New York
Philadelphia
Harrisburg
Washington
Richmond
Norfolk
Raleigh
Hatteras
Charleston
Wilmington
Columbia
Atlanta
Knoxville
Nashville
Lexington
Memphis
Little Rock
Birmingham
Jackson
Shreveport
Oklahoma City
Amarillo
Albuquerque
Phoenix
Yuma
Las Vegas
El Paso
Abilene
Fort Worth
San Antonio
Del Rio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
Caribou
Portland
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES

NOTE: CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

THESE SMOOTHED CHARTS ARE BASED ON THE PERIOD 1931-60



NORMAL DAILY MINIMUM TEMPERATURE (°F), JULY

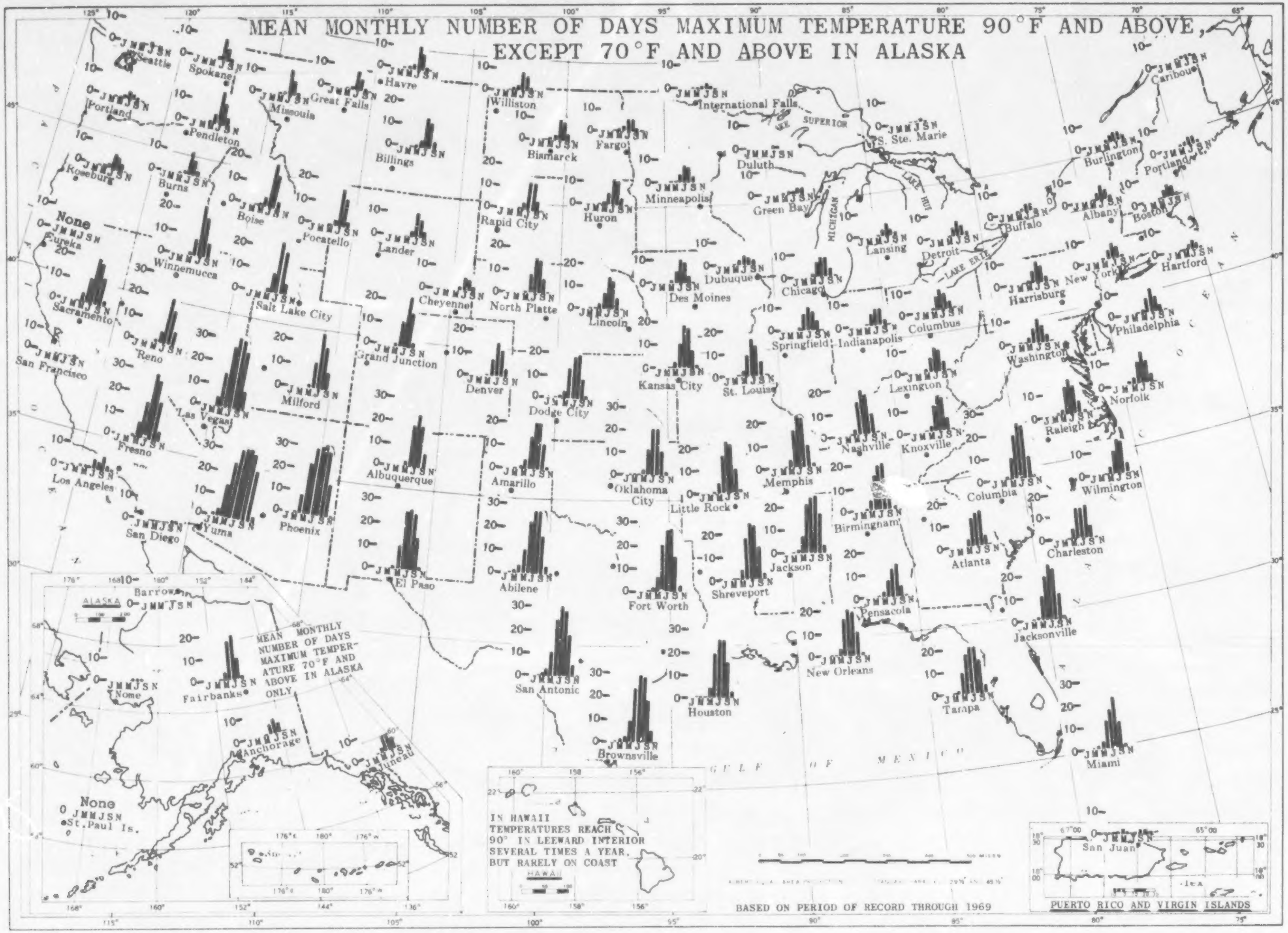
SCALE OF SHADES
30° – 40°
40° – 50°
50° – 60°
60° – 70°
70° – 80°
80° – 90°
90° – 100°
International Falls
LAKE SUPERIOR
S. Ste. Marie
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Huron
Dubuque
Chicago
Detroit
North Platte
Lincoln
Springfield
Indianapolis
Columbus
Pittsburgh
Philadelphia
Kansas City
St. Louis
Lexington
Richmond
Norfolk
Dodge City
Nashville
Raleigh
Amarillo
Oklahoma City
Memphis
Birmingham
Atlanta
Columbia
Charleston
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
Phoenix
Yuma
Winnemucca
Reno
Boise
Rapid City
Fargo
Bismarck
Duluth
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALASKA
Barrow
Barter
INSUFFICIENT DATA FOR ISOLINES AND SHADING
ARCTIC CIRCLE
Fairbanks
Yukon
Nome
Bethel
Kodiak
Yakutat
Juneau
Sitka
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAPS
PUERTO RICO AND VIRGIN ISLANDS
San Juan
Alex. Hamilton Fld.
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°
MILES

NOTE: CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

THESE SMOOTHED CHARTS ARE BASED ON THE PERIOD 1931-60

Map 8

MEAN MONTHLY NUMBER OF DAYS MAXIMUM TEMPERATURE 90°F AND ABOVE, EXCEPT 70°F AND ABOVE IN ALASKA


J M M J S N
0-
10-
20-
30-
Seattle
Spokane
Havre
Williston
International Falls
Caribou
Portland
Pendleton
Missoula
Great Falls
Billings
Bismarck
Fargo
Duluth
S. Ste. Marie
SUPERIOR
Burlington
Portland
Roseburg
Burns
Boise
Pocatello
Lander
Rapid City
Huron
Minneapolis
Green Bay
MICHIGAN
LAKE HURON
Buffalo
Albany
Boston
None
Eureka
Winnemucca
Salt Lake City
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
LAKE ERIE
Harrisburg
New York
Hartford
Sacramento
Reno
Grand Junction
Denver
Dodge City
Kansas City
Springfield
Indianapolis
Columbus
Philadelphia
San Francisco
Milford
St. Louis
Lexington
Washington
Norfolk
Las Vegas
Fresno
Nashville
Knoxville
Raleigh
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Little Rock
Columbia
Wilmington
San Diego
Yuma
Phoenix
El Paso
Abilene
Birmingham
Atlanta
Charleston
Jackson
Shreveport
Fort Worth
Pensacola
Jacksonville
San Antonio
Houston
New Orleans
Tampa
Brownsville
Miami
GULF OF MEXICO
ALASKA
Barrow
Nome
Fairbanks
Anchorage
Juneau
St. Paul Is.
HAWAII
San Juan

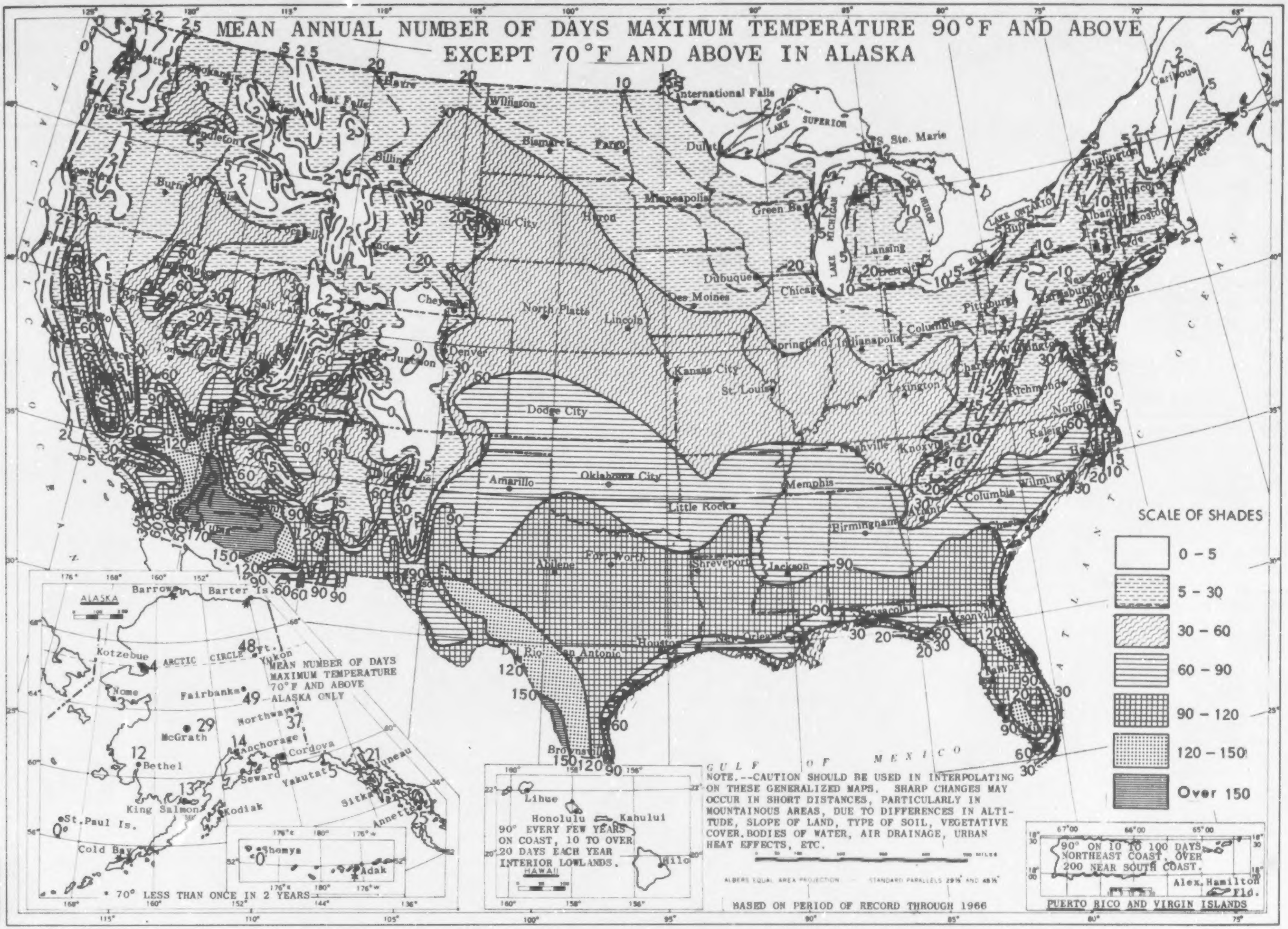
MEAN MONTHLY NUMBER OF DAYS MAXIMUM TEMPERATURE 70°F AND ABOVE IN ALASKA ONLY

IN HAWAII TEMPERATURES REACH 90° IN LEEWARD INTERIOR SEVERAL TIMES A YEAR, BUT RARELY ON COAST

BASED ON PERIOD OF RECORD THROUGH 1969

PUERTO RICO AND VIRGIN ISLANDS

MEAN ANNUAL NUMBER OF DAYS MAXIMUM TEMPERATURE 90°F AND ABOVE EXCEPT 70°F AND ABOVE IN ALASKA

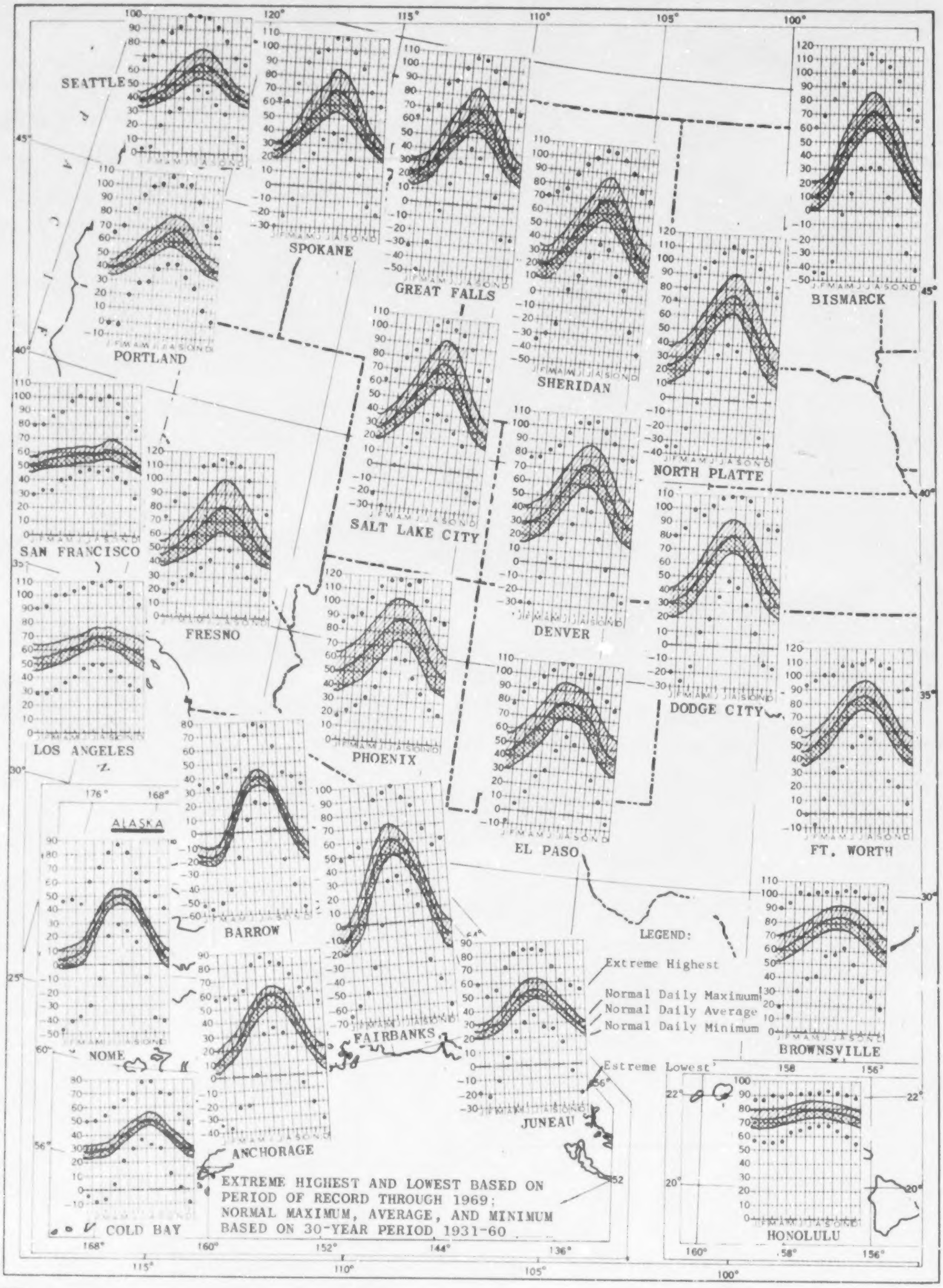

SCALE OF SHADES
0 – 5
5 – 30
30 – 60
60 – 90
90 – 120
120 – 150
Over 150
GULF OF MEXICO
ALASKA
MEAN NUMBER OF DAYS MAXIMUM TEMPERATURE 70°F AND ABOVE ALASKA ONLY
ARCTIC CIRCLE
Barrow
Barter Is.
Kotzebue
Nome
Fairbanks
Ft. Yukon
Northway
McGrath
Anchorage
Cordova
Bethel
Seward
Yakutat
Juneau
Sitka
Annette
King Salmon
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
* 70° LESS THAN ONCE IN 2 YEARS
HAWAII
Lihue
Honolulu
Kahului
Hilo
90° EVERY FEW YEARS ON COAST, 10 TO OVER 20 DAYS EACH YEAR INTERIOR LOWLANDS.
PUERTO RICO AND VIRGIN ISLANDS
90° ON 10 TO 100 DAYS NORTHEAST COAST, OVER 200 NEAR SOUTH COAST.
Alex. Hamilton Fld.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
International Falls
Seattle
Spokane
Portland
Pendleton
Great Falls
Havre
Williston
Billings
Bismarck
Fargo
Duluth
S. Ste. Marie
Burns
Rapid City
Huron
Minneapolis
Green Bay
Lansing
Detroit
Buffalo
Burlington
Albany
Boston
Dubuque
Des Moines
Chicago
Cheyenne
Salt Lake City
North Platte
Lincoln
Denver
Grand Junction
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
New York
Philadelphia
Washington
Charleston
Richmond
Norfolk
Lexington
Dodge City
Nashville
Knoxville
Raleigh
Hatteras
Amarillo
Oklahoma City
Memphis
Little Rock
Birmingham
Atlanta
Columbia
Wilmington
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Tampa
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°
MILES

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

BASED ON PERIOD OF RECORD THROUGH 1966

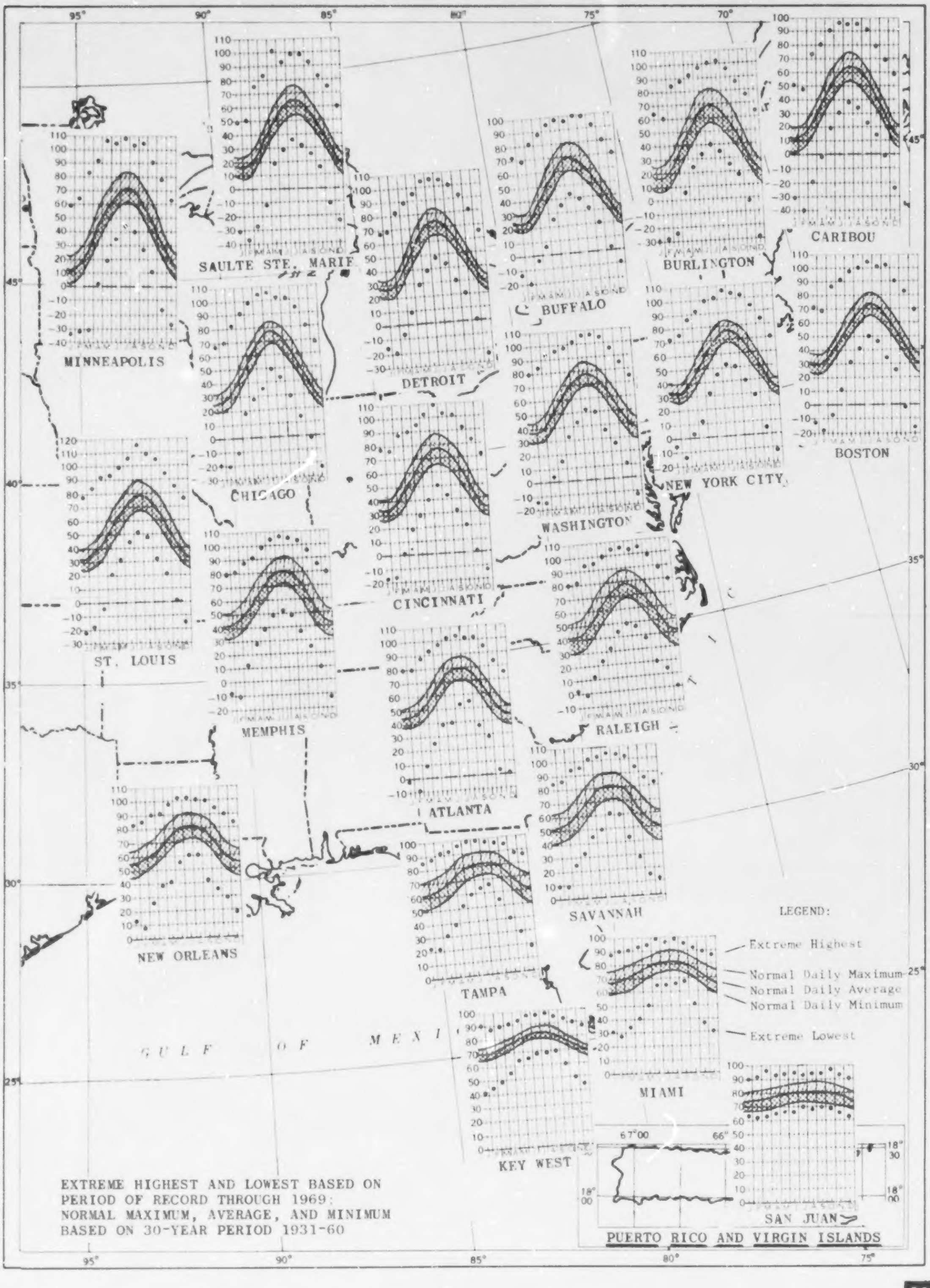
Map 9

Normal Daily Maximum, Average, Minimum, and Extreme Temperature (°F) by Months, Western United States


SEATTLE
SPOKANE
GREAT FALLS
SHERIDAN
BISMARCK
PORTLAND
SALT LAKE CITY
NORTH PLATTE
SAN FRANCISCO
FRESNO
DENVER
DODGE CITY
LOS ANGELES
PHOENIX
EL PASO
FT. WORTH
ALASKA
BARROW
NOME
FAIRBANKS
ANCHORAGE
JUNEAU
COLD BAY
BROWNSVILLE
HONOLULU
LEGEND:
Extreme Highest
Normal Daily Maximum
Normal Daily Average
Normal Daily Minimum
Extreme Lowest
J F M A M J J A S O N D
EXTREME HIGHEST AND LOWEST BASED ON PERIOD OF RECORD THROUGH 1969; NORMAL MAXIMUM, AVERAGE, AND MINIMUM BASED ON 30-YEAR PERIOD 1931-60
120°
115°
110°
105°
100°
45°
40°
35°
30°
25°
176°
168°
160°
152°
144°
136°
158°
156°
22°
20°

Map 10

Normal Daily Maximum, Average, Minimum, and Extreme Temperature (°F), by Months, Eastern United States

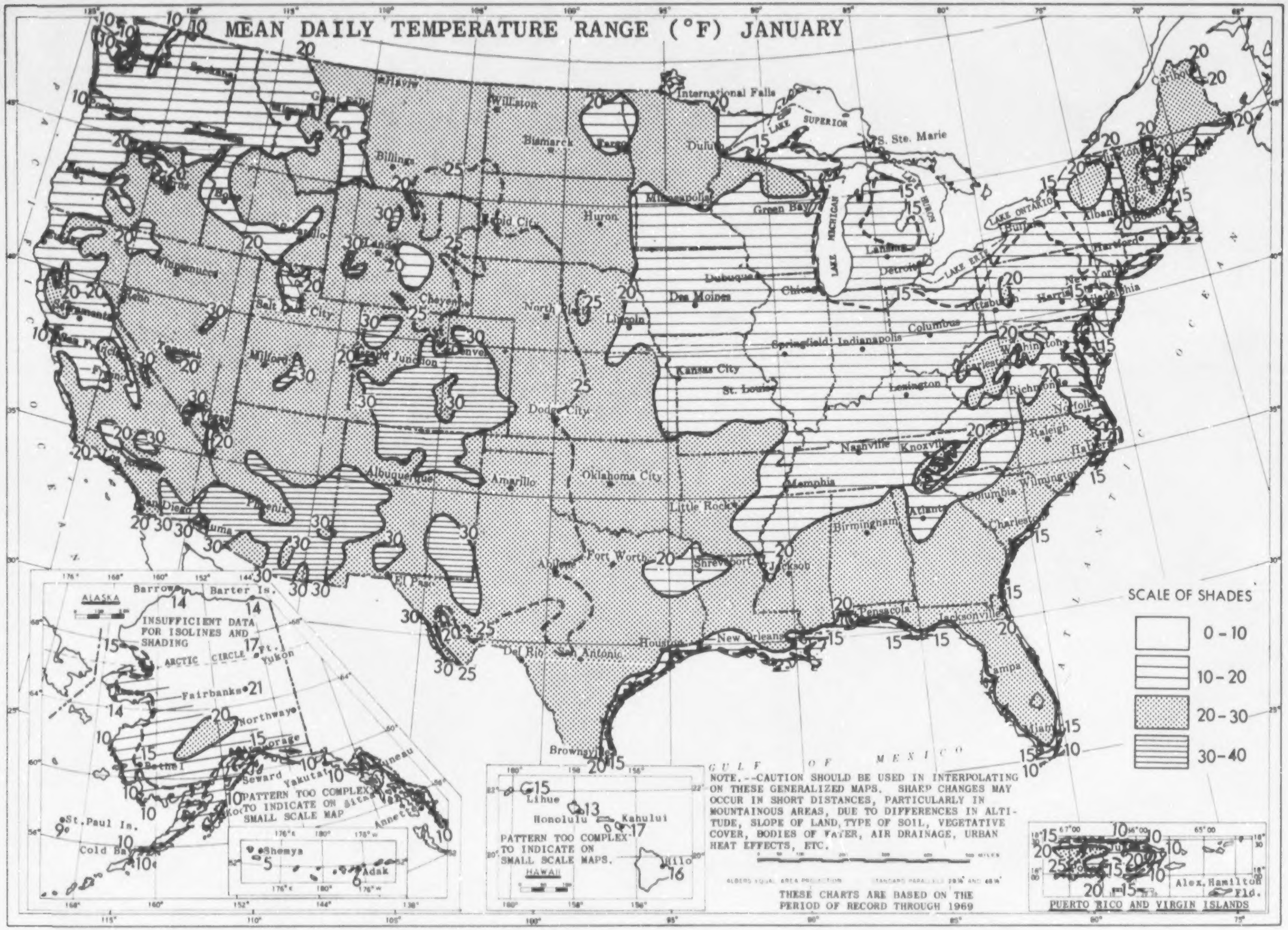

MINNEAPOLIS
SAULTE STE. MARIE
DETROIT
BUFFALO
BURLINGTON
CARIBOU
BOSTON
CHICAGO
NEW YORK CITY
WASHINGTON
ST. LOUIS
CINCINNATI
MEMPHIS
RALEIGH
ATLANTA
NEW ORLEANS
SAVANNAH
TAMPA
MIAMI
KEY WEST
SAN JUAN
PUERTO RICO AND VIRGIN ISLANDS
G U L F   O F   M E X I
LEGEND:
Extreme Highest
Normal Daily Maximum
Normal Daily Average
Normal Daily Minimum
Extreme Lowest
95°
90°
85°
80°
75°
70°
45°
40°
35°
30°
25°
67°00
66°
18° 30
18° 00

EXTREME HIGHEST AND LOWEST BASED ON
PERIOD OF RECORD THROUGH 1969;
NORMAL MAXIMUM, AVERAGE, AND MINIMUM
BASED ON 30-YEAR PERIOD 1931-60

Map 11

Map 12.

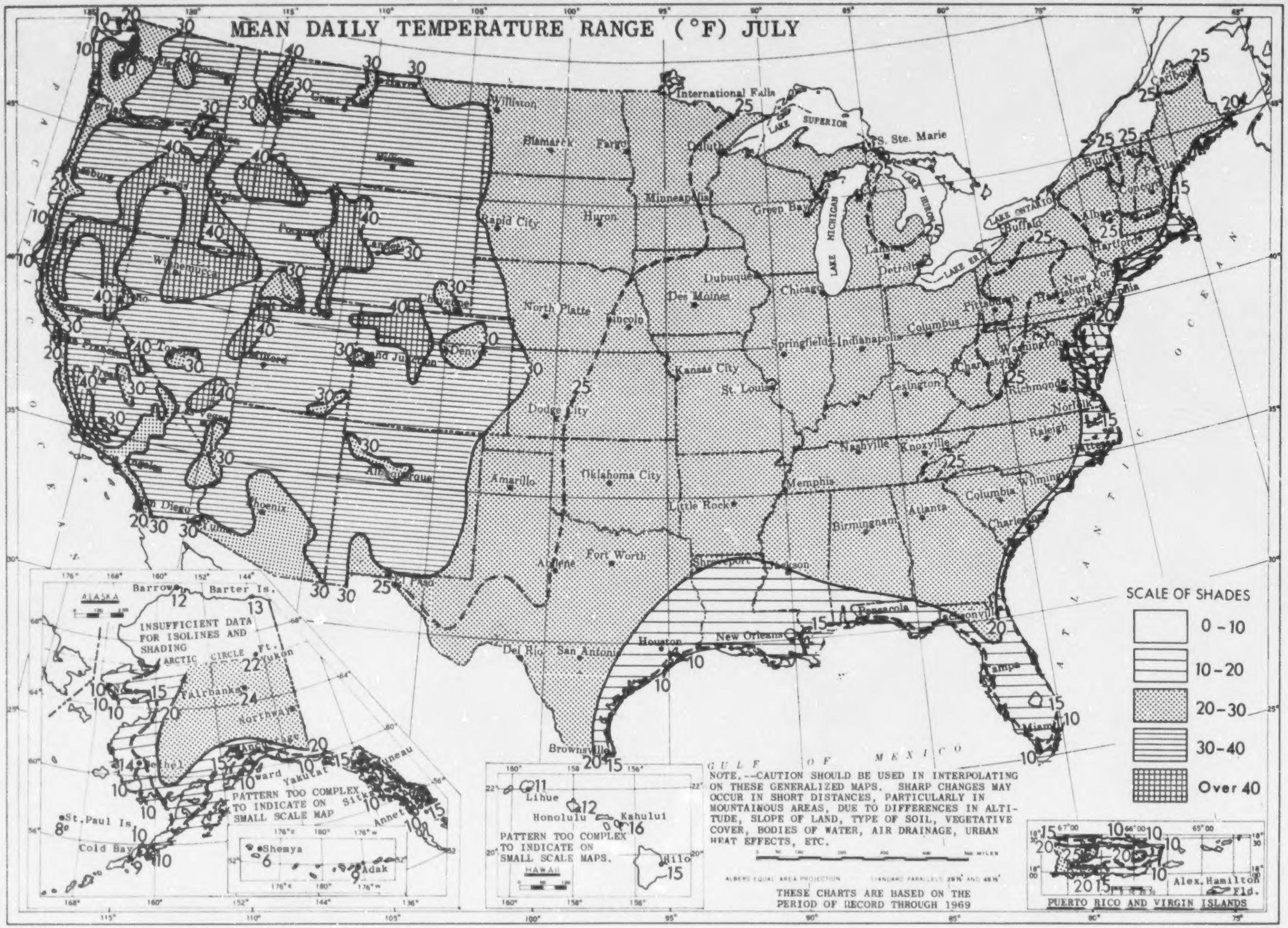
MEAN DAILY TEMPERATURE RANGE (°F) JANUARY


Spokane
Havre
Great Falls
Williston
Bismarck
Fargo
International Falls
Duluth
LAKE SUPERIOR
S. Ste. Marie
Caribou
Billings
Boise
Pocatello
Lander
Rapid City
Huron
Minneapolis
Green Bay
LAKE MICHIGAN
LAKE HURON
Lansing
Detroit
LAKE ONTARIO
Buffalo
Albany
Boston
Hartford
LAKE ERIE
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Salt Lake City
Milford
Cheyenne
Grand Junction
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
New York
Philadelphia
Washington
Kansas City
St. Louis
Lexington
Richmond
Norfolk
Dodge City
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
10
15
20
25
30
ALASKA
Barrow
Barter Is.
INSUFFICIENT DATA FOR ISOLINES AND SHADING
ARCTIC CIRCLE
Ft. Yukon
Fairbanks 21
Northway
Anchorage
Bethel
Seward
Yakutat
Juneau
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAP
Shemya
Adak
14
17
9
5
6
HAWAII
Lihue
Honolulu
Kahului
Hilo
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAPS.
13
16
PUERTO RICO AND VIRGIN ISLANDS
Alex. Hamilton Fld.
SCALE OF SHADES
0 - 10
10 - 20
20 - 30
30 - 40
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

THESE CHARTS ARE BASED ON THE PERIOD OF RECORD THROUGH 1969

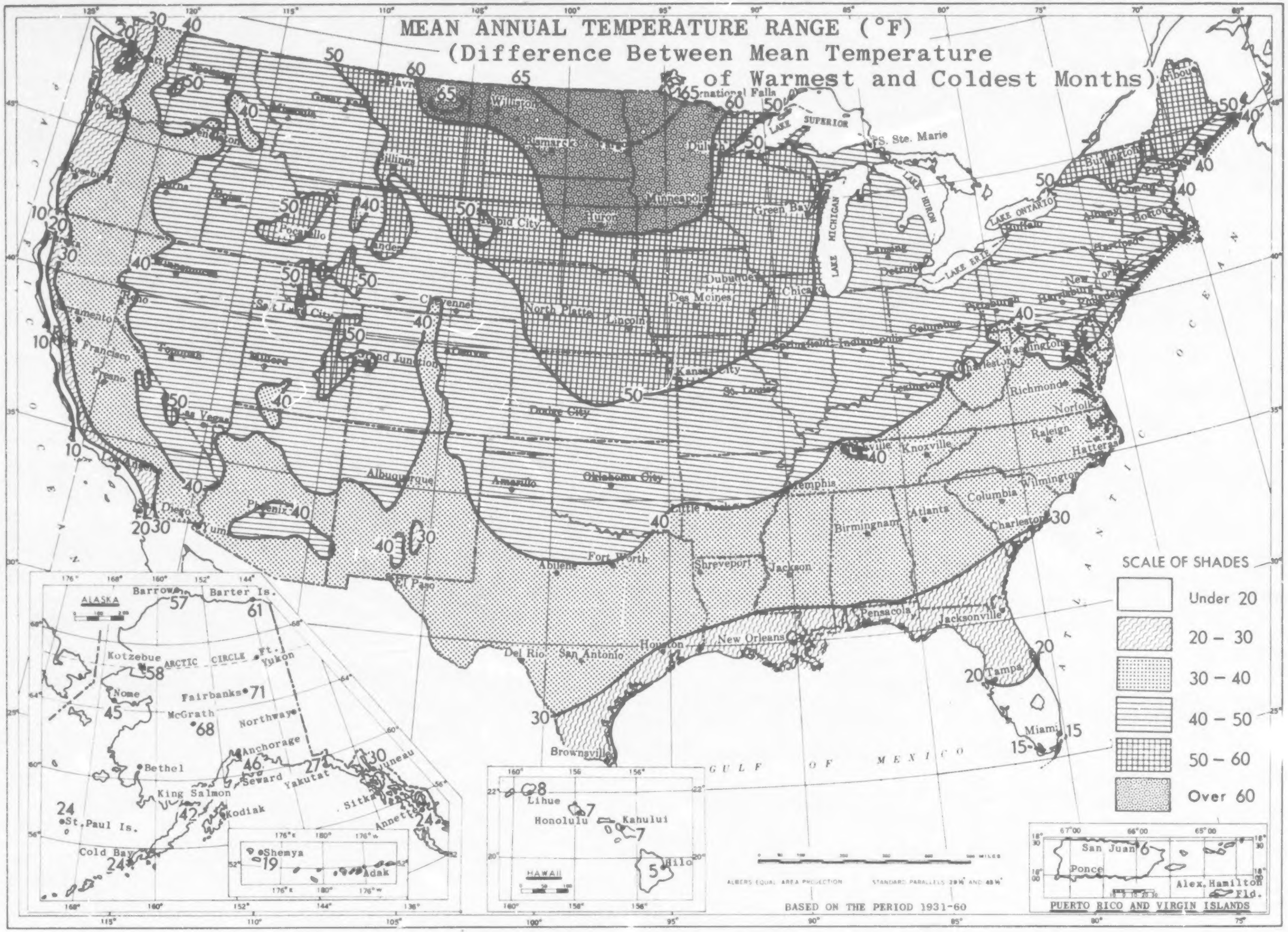
MEAN DAILY TEMPERATURE RANGE (°F) JULY


SCALE OF SHADES
0 - 10
10 - 20
20 - 30
30 - 40
Over 40
ALASKA
INSUFFICIENT DATA FOR ISOLINES AND SHADING
ARCTIC CIRCLE
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAP
HAWAII
PATTERN TOO COMPLEX TO INDICATE ON SMALL SCALE MAPS.
PUERTO RICO AND VIRGIN ISLANDS
Alex. Hamilton Fld.
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
0 50 100 200 300 400 500 MILES

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

THESE CHARTS ARE BASED ON THE PERIOD OF RECORD THROUGH 1969

Map 14



MEAN ANNUAL TEMPERATURE RANGE (°F)
(Difference Between Mean Temperature of Warmest and Coldest Months)

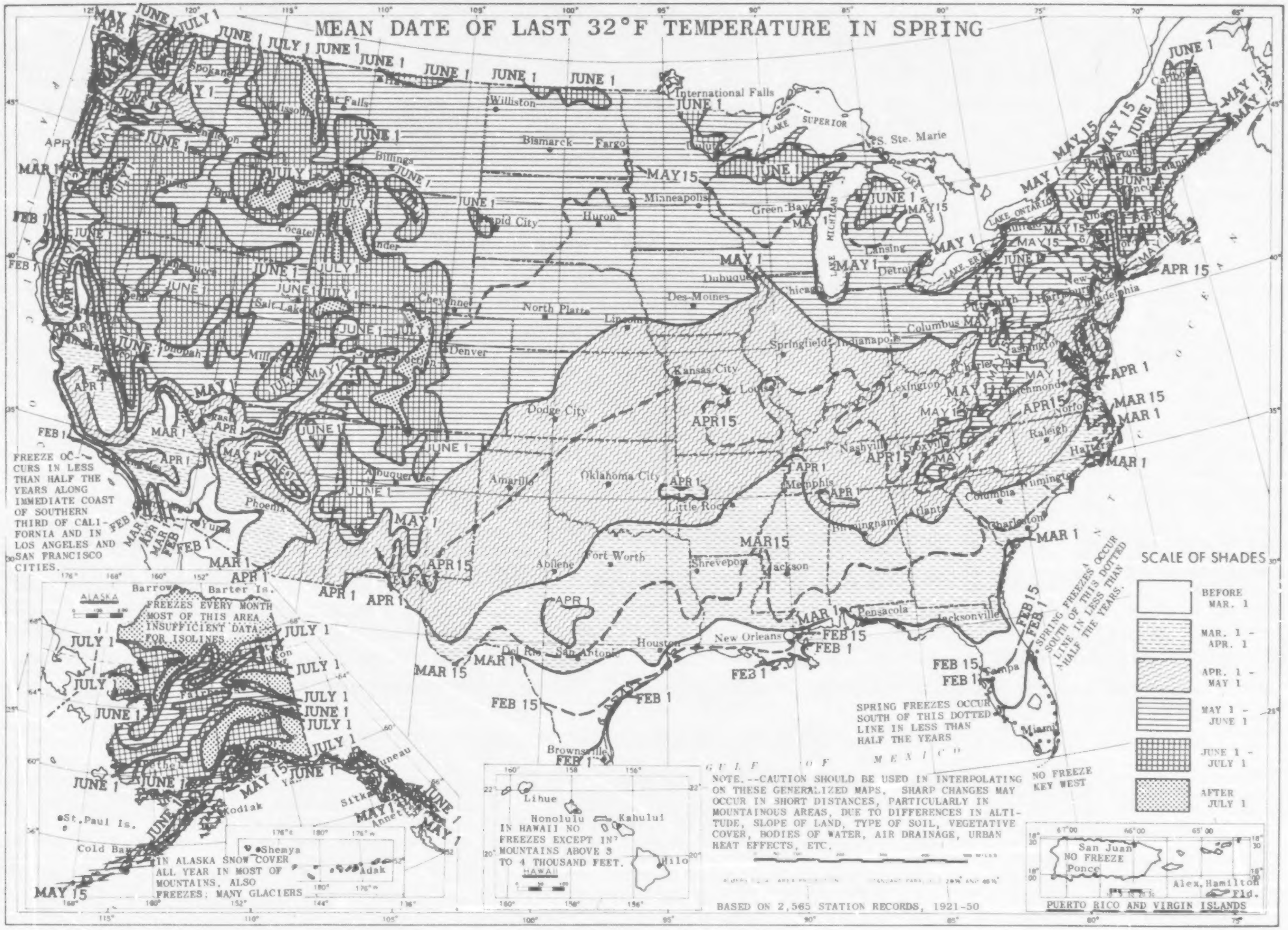
SCALE OF SHADES
Under 20
20 – 30
30 – 40
40 – 50
50 – 60
Over 60
ALASKA
Barrow 57
Barter Is. 61
Kotzebue 58
ARCTIC CIRCLE
Ft. Yukon
Nome 45
Fairbanks 71
McGrath 68
Northway
Anchorage 46
Bethel
Seward
Yakutat 27
Juneau 30
Sitka
Annette 24
King Salmon 42
Kodiak
St. Paul Is. 24
Cold Bay 24
Shemya 19
Adak
HAWAII
Lihue 8
Honolulu 7
Kahului 7
Hilo 5
PUERTO RICO AND VIRGIN ISLANDS
San Juan 6
Ponce
Alex. Hamilton Fld.
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Seattle
Portland
Spokane
Boise
Pocatello
Salt Lake City
Reno
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Yuma
Las Vegas
Phoenix
Albuquerque
El Paso
Cheyenne
Denver
Grand Junction
Lander
Billings
Great Falls
Williston
Bismarck
Rapid City
Huron
Minneapolis
Duluth
International Falls
Green Bay
S. Ste. Marie
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Detroit
Lansing
Buffalo
Pittsburgh
Harrisburg
Philadelphia
New York
Hartford
Albany
Boston
Burlington
Portland
Caribou
Washington
Charleston
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Knoxville
Nashville
Lexington
Memphis
Little Rock
Atlanta
Birmingham
Jackson
Shreveport
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Dodge City
Amarillo
Oklahoma City
Fort Worth
Abilene
Del Rio
San Antonio
Houston
Brownsville
Tonopah
Milford
Winnemucca
Roseburg
Eureka
10
20
30
40
50
60
65
15
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES

BASED ON THE PERIOD 1931-60

64

Map 15

MEAN DATE OF LAST 32°F TEMPERATURE IN SPRING



JUNE 1
JULY 1
MAY 15
MAY 1
APR 15
APR 1
MAR 15
MAR 1
FEB 15
FEB 1
Spokane
Great Falls
Missoula
Pendleton
Billings
Boise
Pocatello
Lander
Reno
Salt Lake
Cheyenne
Denver
Tonopah
Milford
Albuquerque
Phoenix
Yuma
Los Angeles
Williston
Bismarck
Fargo
Rapid City
Huron
Minneapolis
North Platte
Lincoln
Des Moines
Dubuque
Kansas City
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
Shreveport
Little Rock
Memphis
Jackson
New Orleans
International Falls
LAKE SUPERIOR
S. Ste. Marie
Duluth
Green Bay
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Chicago
Lansing
Detroit
Springfield
Indianapolis
St. Louis
Columbus
Pittsburgh
Harrisburg
Philadelphia
New York
Washington
Charleston
Lexington
Nashville
Knoxville
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Atlanta
Birmingham
Charleston
Pensacola
Jacksonville
Tampa
Miami
Burlington
Portland
Concord
Albany
Boston
Caribou
GULF OF MEXICO
ALASKA
Barrow
Barter Is.
Fairbanks
Bethel
Kodiak
Yakutat
Juneau
Sitka
Annette
St.Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex.Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

FREEZE OCCURS IN LESS THAN HALF THE YEARS ALONG IMMEDIATE COAST OF SOUTHERN THIRD OF CALIFORNIA AND IN LOS ANGELES AND SAN FRANCISCO CITIES.

FREEZES EVERY MONTH MOST OF THIS AREA INSUFFICIENT DATA FOR ISOLINES

IN ALASKA SNOW COVER ALL YEAR IN MOST OF MOUNTAINS. ALSO FREEZES; MANY GLACIERS

IN HAWAII NO FREEZES EXCEPT IN MOUNTAINS ABOVE 3 TO 4 THOUSAND FEET.

SPRING FREEZES OCCUR SOUTH OF THIS DOTTED LINE IN LESS THAN HALF THE YEARS.

SPRING FREEZES OCCUR SOUTH OF THIS DOTTED LINE IN LESS THAN HALF THE YEARS

NO FREEZE KEY WEST

NO FREEZE

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

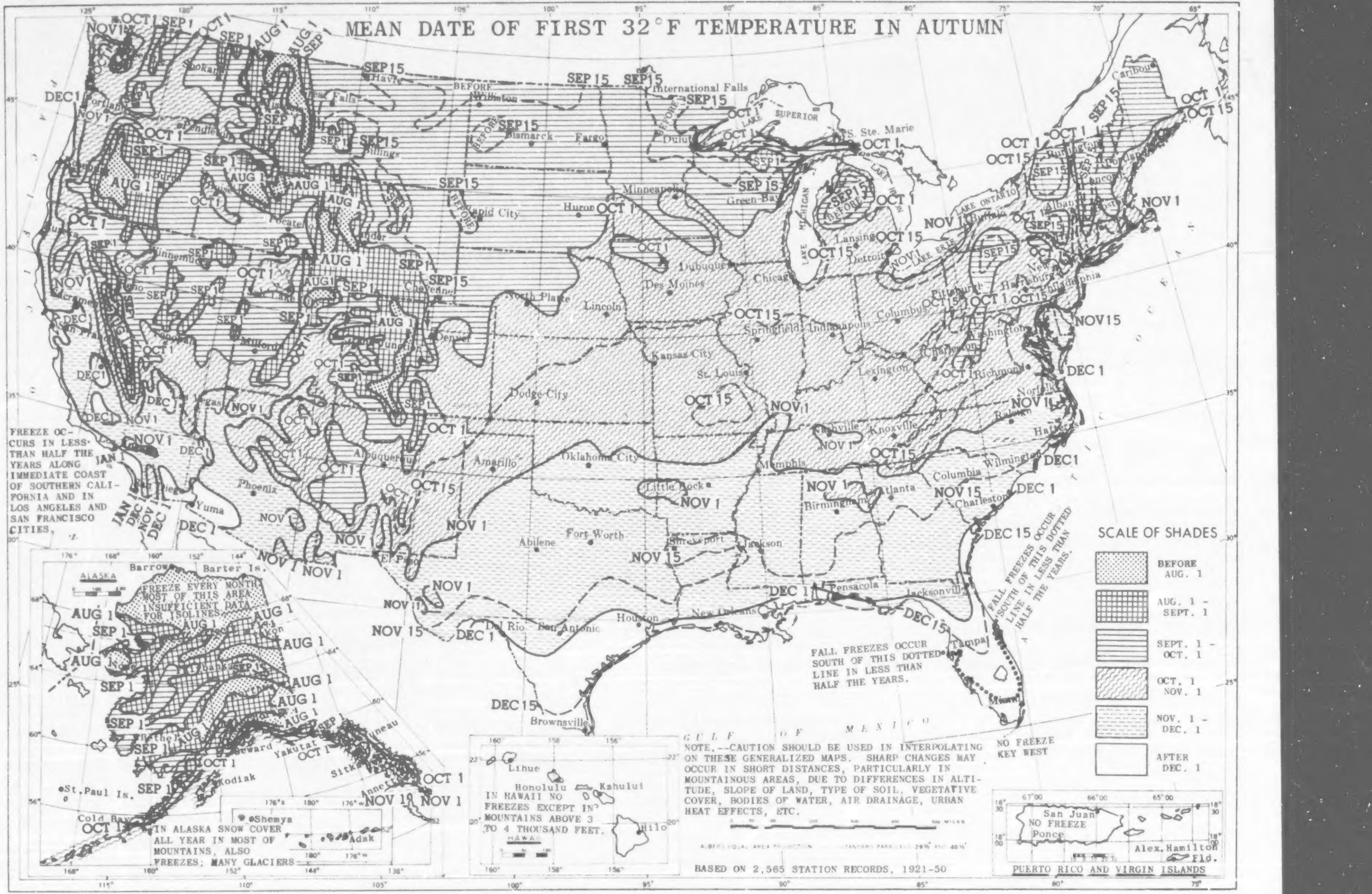
BASED ON 2,565 STATION RECORDS, 1921-50

SCALE OF SHADES

☐	BEFORE MAR. 1
▨	MAR. 1 - APR. 1
▨	APR. 1 - MAY 1
▤	MAY 1 - JUNE 1
▦	JUNE 1 - JULY 1
▩	AFTER JULY 1

Map 16

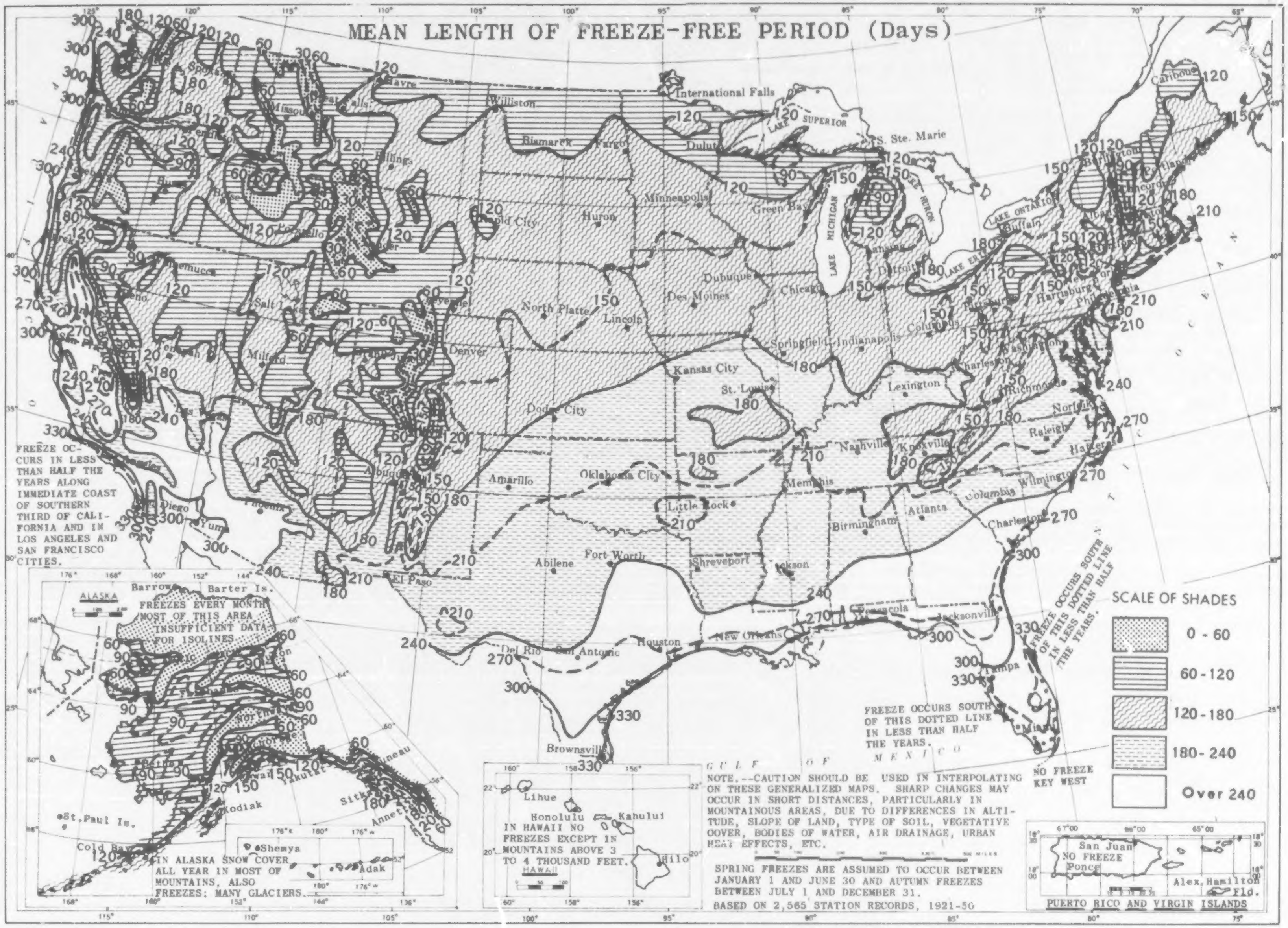
MEAN DATE OF FIRST 32°F TEMPERATURE IN AUTUMN


MEAN DATE OF FIRST 32°F TEMPERATURE IN AUTUMN
SCALE OF SHADES
BEFORE AUG. 1
AUG. 1 - SEPT. 1
SEPT. 1 - OCT. 1
OCT. 1 NOV. 1
NOV. 1 - DEC. 1
AFTER DEC. 1
FREEZE OCCURS IN LESS THAN HALF THE YEARS ALONG IMMEDIATE COAST OF SOUTHERN CALIFORNIA AND IN LOS ANGELES AND SAN FRANCISCO CITIES.
FALL FREEZES OCCUR SOUTH OF THIS DOTTED LINE IN LESS THAN HALF THE YEARS.
NO FREEZE KEY WEST
GULF OF MEXICO
ALASKA
FREEZE EVERY MONTH MOST OF THIS AREA INSUFFICIENT DATA FOR ISOLINES
IN ALASKA SNOW COVER ALL YEAR IN MOST OF MOUNTAINS, ALSO FREEZES; MANY GLACIERS
HAWAII
IN HAWAII NO FREEZES EXCEPT IN MOUNTAINS ABOVE 3 TO 4 THOUSAND FEET.
Lihue
Honolulu
Kahului
Hilo
PUERTO RICO AND VIRGIN ISLANDS
San Juan
NO FREEZE
Ponce
Alex. Hamilton Fld.
ALBERS EQUAL AREA PROJECTION
International Falls
SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
SEP 15
OCT 1
OCT 15
NOV 1
NOV 15
DEC 1
DEC 15
JAN 1
AUG 1
SEP 1

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

BASED ON 2,565 STATION RECORDS, 1921-50

Map 17



MEAN LENGTH OF FREEZE-FREE PERIOD (Days)

SCALE OF SHADES
0 - 60
60 - 120
120 - 180
180 - 240
Over 240
ALASKA
HAWAII
PUERTO RICO AND VIRGIN ISLANDS
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
International Falls
Williston
Bismarck
Fargo
Duluth
S. Ste. Marie
Caribou
Minneapolis
Green Bay
Huron
Rapid City
Billings
Havre
Great Falls
Spokane
Boise
Pocatello
Winnemucca
Reno
Salt Lake
Cheyenne
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Detroit
Buffalo
Burlington
Concord
Albany
Pittsburgh
Harrisburg
Philadelphia
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Columbus
Indianapolis
Springfield
Kansas City
St. Louis
Lexington
Nashville
Knoxville
Memphis
Little Rock
Oklahoma City
Dodge City
Amarillo
Albuquerque
Milford
Tonopah
Phoenix
Yuma
San Diego
Los Angeles
Fresno
Las Vegas
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Birmingham
Atlanta
Pensacola
Jacksonville
Tampa
Miami
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Barrow
Barter Is.
Nome
Bethel
Kodiak
Cold Bay
St. Paul Is.
Yakutat
Sitka
Juneau
Annette
Shemya
Adak
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.

FREEZE OCCURS IN LESS THAN HALF THE YEARS ALONG IMMEDIATE COAST OF SOUTHERN THIRD OF CALIFORNIA AND IN LOS ANGELES AND SAN FRANCISCO CITIES.

FREEZES EVERY MONTH MOST OF THIS AREA INSUFFICIENT DATA FOR ISOLINES.

IN ALASKA SNOW COVER ALL YEAR IN MOST OF MOUNTAINS, ALSO FREEZES; MANY GLACIERS.

IN HAWAII NO FREEZES EXCEPT IN MOUNTAINS ABOVE 3 TO 4 THOUSAND FEET.

FREEZE OCCURS SOUTH OF THIS DOTTED LINE IN LESS THAN HALF THE YEARS.

FREEZE OCCURS SOUTH OF THIS DOTTED LINE IN LESS THAN HALF THE YEARS.

NO FREEZE KEY WEST

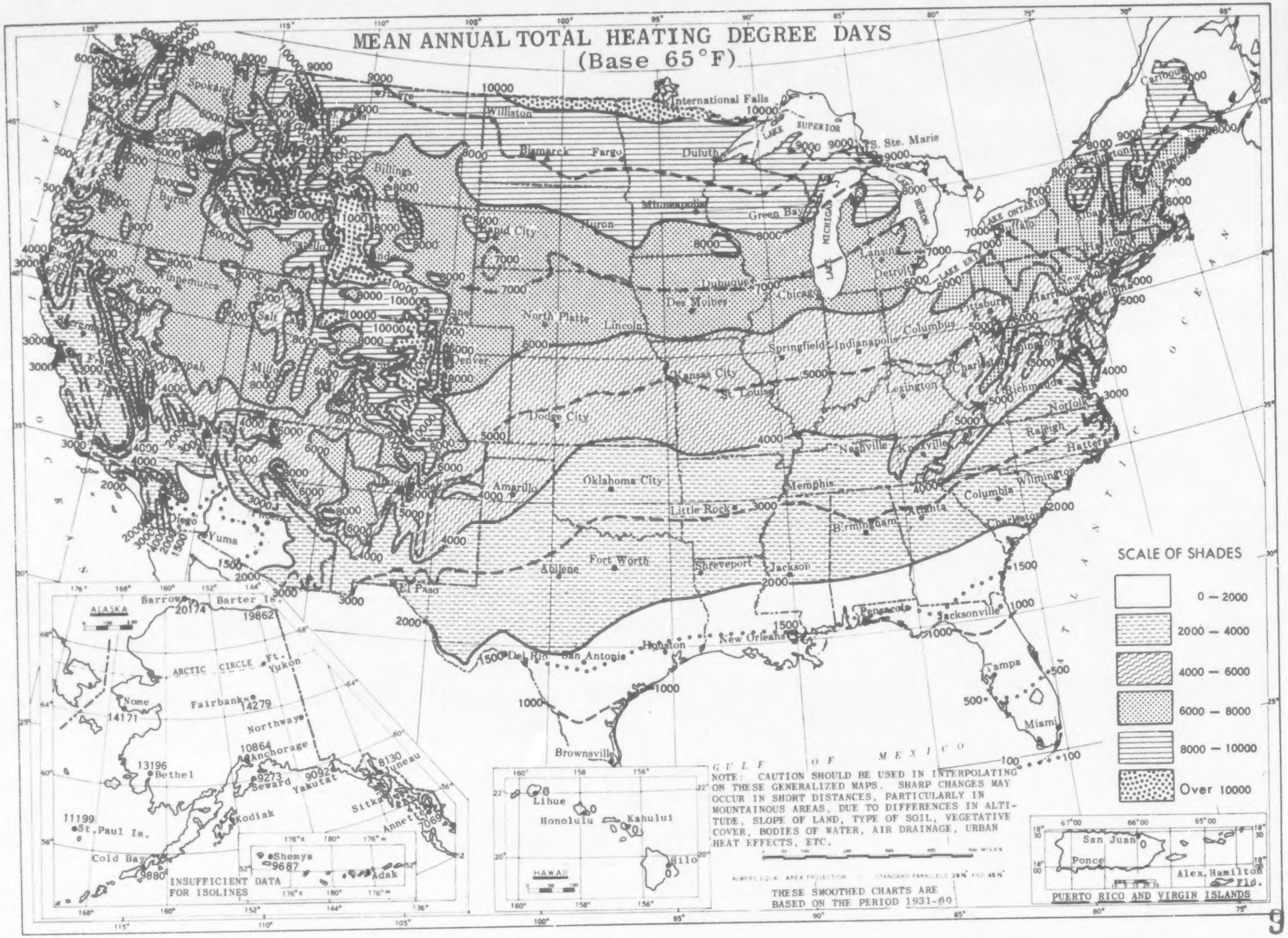
NO FREEZE

NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

SPRING FREEZES ARE ASSUMED TO OCCUR BETWEEN JANUARY 1 AND JUNE 30 AND AUTUMN FREEZES BETWEEN JULY 1 AND DECEMBER 31.

BASED ON 2,565 STATION RECORDS, 1921-50

Map 18



MEAN ANNUAL TOTAL HEATING DEGREE DAYS
(Base 65°F)

NOTE: CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

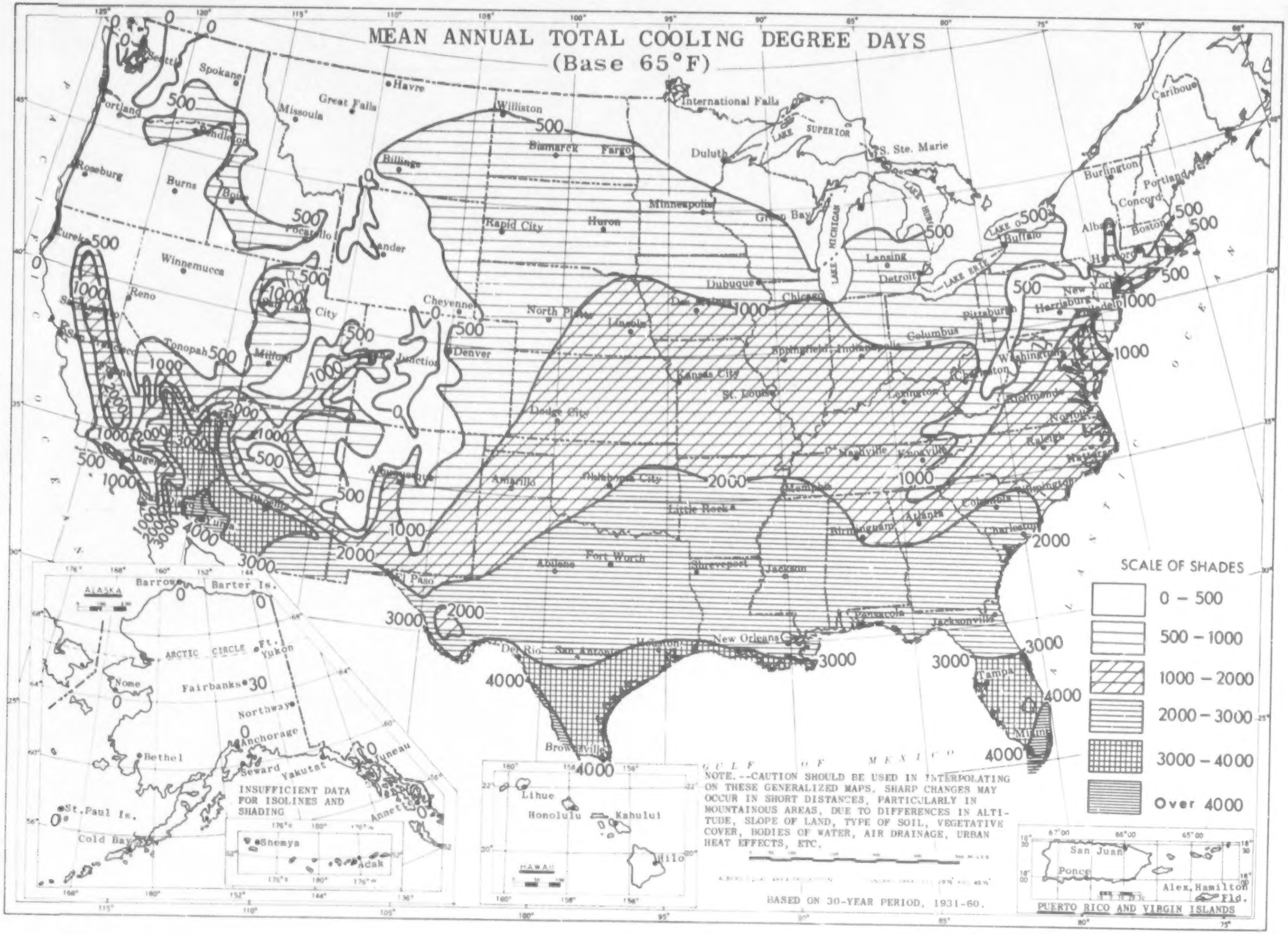
THESE SMOOTHED CHARTS ARE BASED ON THE PERIOD 1931-60

ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°

SCALE OF SHADES
▭ 0 — 2000
▤ 2000 — 4000
▨ 4000 — 6000
▩ 6000 — 8000
▤ 8000 — 10000
⁘ Over 10000
ALASKA
Barrow 20174
Barter Is. 19862
ARCTIC CIRCLE
Ft. Yukon
Nome 14171
Fairbanks 14279
Northway
Bethel 13196
Anchorage 10864
Seward 9273
Yakutat 9092
Juneau 8130
Sitka
Annette 7069
Kodiak
St. Paul Is. 11199
Cold Bay 9880
Shemya 9687
Adak
INSUFFICIENT DATA FOR ISOLINES
HAWAII
Lihue 0
Honolulu 0
Kahului
Hilo 0
PUERTO RICO AND VIRGIN ISLANDS
San Juan 0
Ponce
Alex. Hamilton Fld.
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
International Falls
Williston
Bismarck
Fargo
Duluth
Sault Ste. Marie
Caribou
Burlington
Spokane
Billings
Rapid City
Huron
Minneapolis
Green Bay
Lansing
Detroit
Buffalo
Albany
Hartford
Boston
Portland
Boise
Pocatello
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Pittsburgh
Philadelphia
Winnemucca
Salt Lake City
Denver
Springfield
Indianapolis
Columbus
Charleston
Washington
Reno
Tonopah
Milford
Kansas City
St. Louis
Lexington
Richmond
Norfolk
Dodge City
Raleigh
Hatteras
Nashville
Knoxville
Amarillo
Oklahoma City
Little Rock
Memphis
Atlanta
Birmingham
Columbia
Wilmington
Charleston
San Diego
Yuma
Phoenix
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
1000
1500
2000
3000
4000
5000
6000
7000
8000
9000
10000
500
100

Map 19

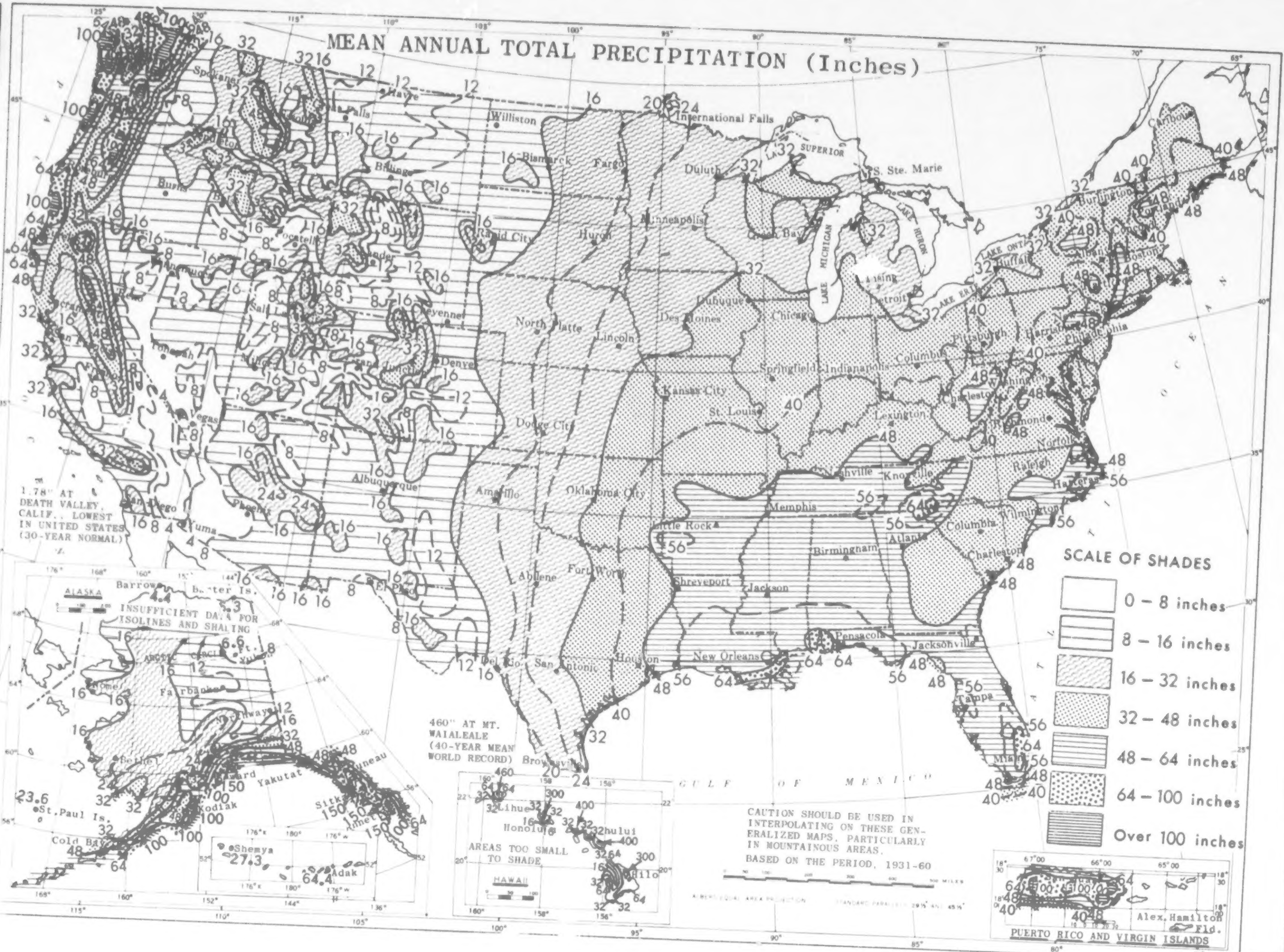
MEAN ANNUAL TOTAL COOLING DEGREE DAYS
(Base 65°F)


SCALE OF SHADES
0 – 500
500 – 1000
1000 – 2000
2000 – 3000
3000 – 4000
Over 4000
ALASKA
INSUFFICIENT DATA FOR ISOLINES AND SHADING
HAWAII
PUERTO RICO AND VIRGIN ISLANDS
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
500
1000
2000
3000
4000

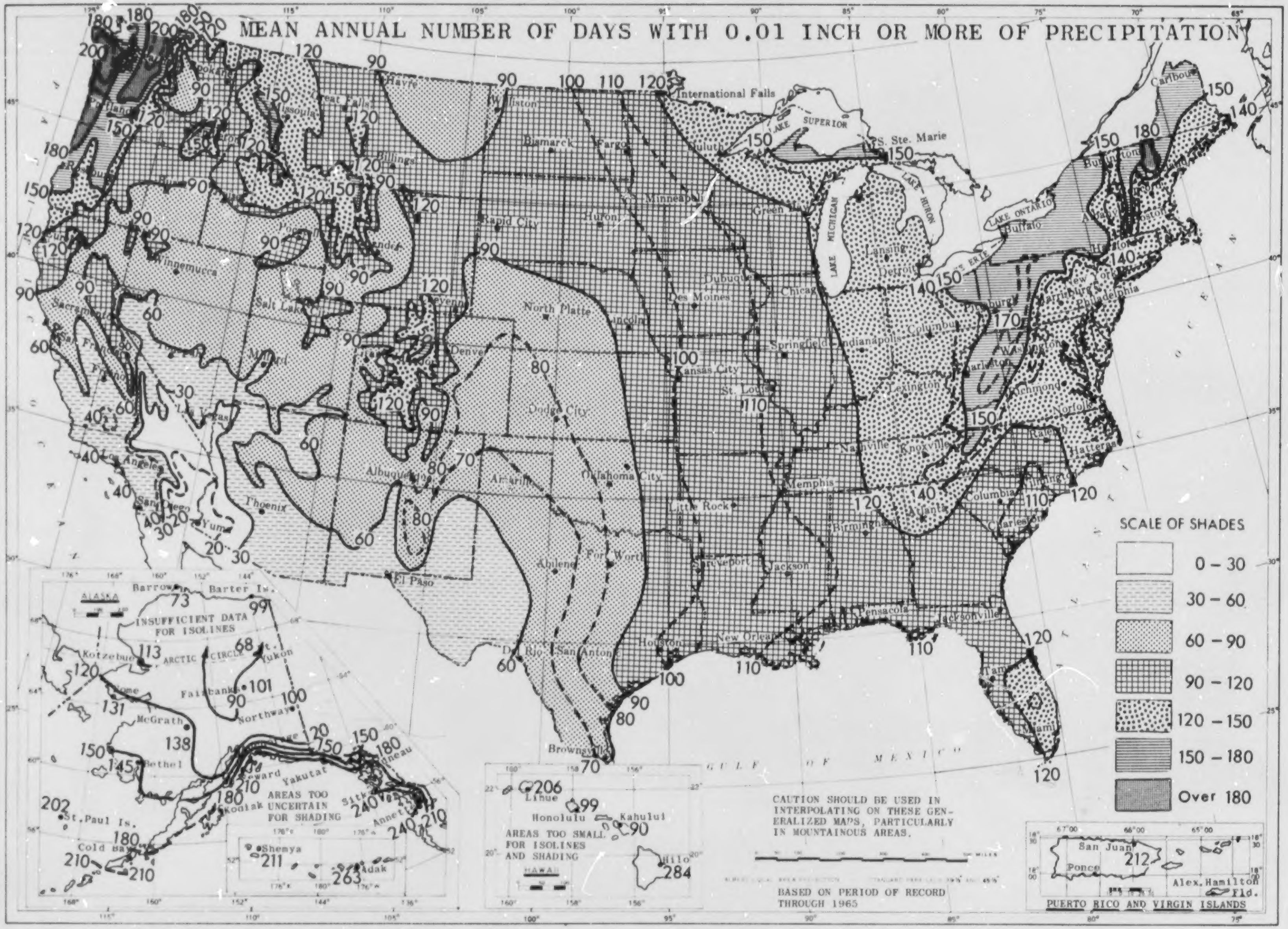
NOTE.--CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS. SHARP CHANGES MAY OCCUR IN SHORT DISTANCES, PARTICULARLY IN MOUNTAINOUS AREAS, DUE TO DIFFERENCES IN ALTITUDE, SLOPE OF LAND, TYPE OF SOIL, VEGETATIVE COVER, BODIES OF WATER, AIR DRAINAGE, URBAN HEAT EFFECTS, ETC.

BASED ON 30-YEAR PERIOD, 1931-60.

Map 20


MEAN ANNUAL TOTAL PRECIPITATION (Inches)
SCALE OF SHADES
0 – 8 inches
8 – 16 inches
16 – 32 inches
32 – 48 inches
48 – 64 inches
64 – 100 inches
Over 100 inches
1.78" AT DEATH VALLEY, CALIF., LOWEST IN UNITED STATES (30-YEAR NORMAL)
460" AT MT. WAIALEALE (40-YEAR MEAN WORLD RECORD)
CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.
BASED ON THE PERIOD, 1931-60
ALASKA
INSUFFICIENT DATA FOR ISOLINES AND SHADING
HAWAII
AREAS TOO SMALL TO SHADE
PUERTO RICO AND VIRGIN ISLANDS
GULF OF MEXICO
SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Spokane
Havre
Williston
Bismarck
Fargo
International Falls
Duluth
S. Ste. Marie
Caribou
Burlington
Albany
Boston
Burns
Billings
Rapid City
Huron
Minneapolis
Pocatello
Lander
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
Buffalo
Pittsburgh
Harrisburg
Philadelphia
Salt Lake
Grand Junction
Denver
Kansas City
Springfield
Indianapolis
Columbus
Washington
Charleston
Lexington
Richmond
Norfolk
St. Louis
Dodge City
Vegas
Albuquerque
Amarillo
Oklahoma City
Nashville
Knoxville
Raleigh
Hatteras
Memphis
Little Rock
Atlanta
Columbia
Wilmington
Charleston
Birmingham
San Diego
Yuma
Phoenix
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
Barrow
Barter Is.
Nome
Fairbanks
Northway
Bethel
Seward
Yakutat
Juneau
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
Lihue
Honolulu
Kahului
Hilo
Alex. Hamilton Fld.
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES

Map 21

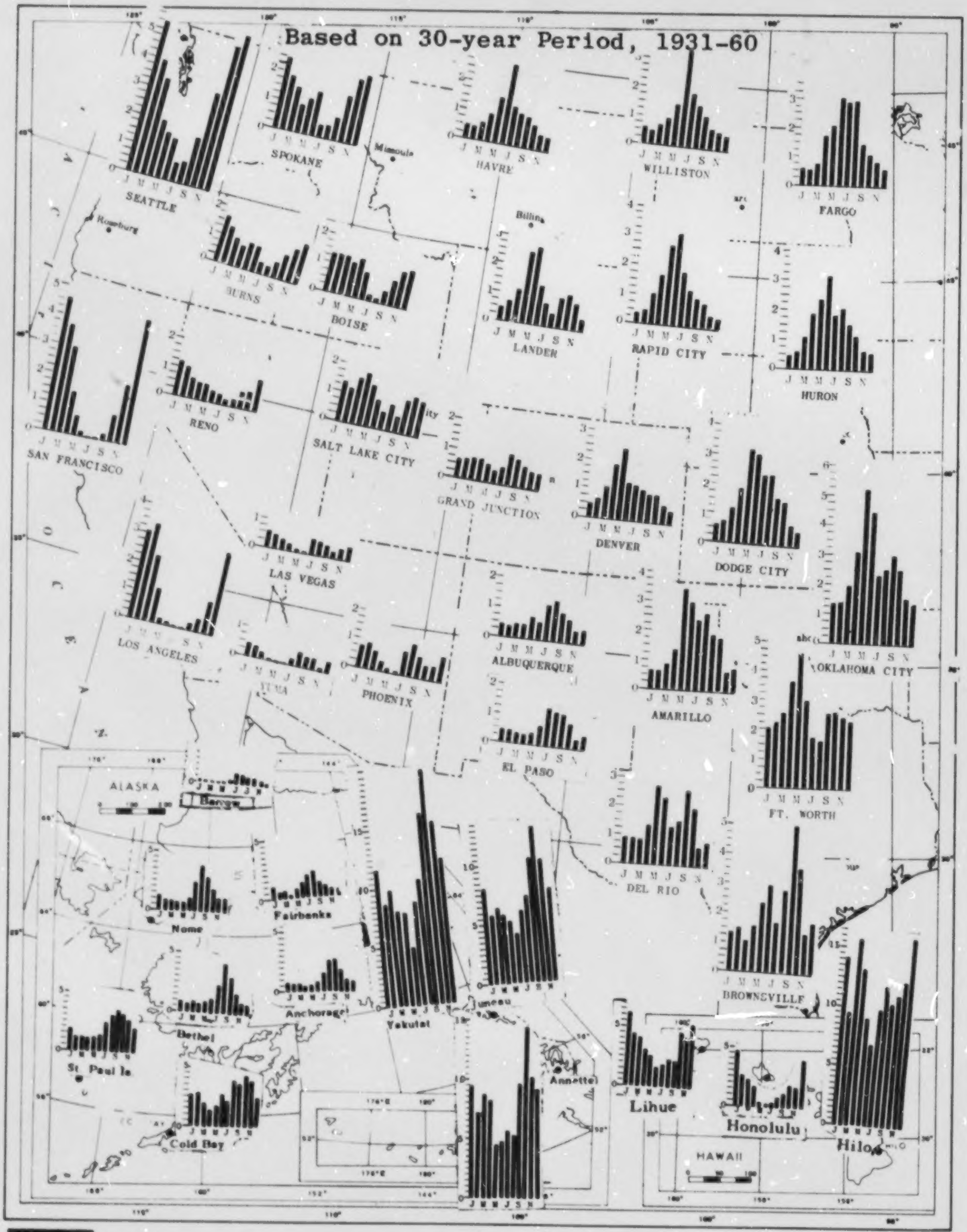

SCALE OF SHADES
0 – 30
30 – 60
60 – 90
90 – 120
120 – 150
150 – 180
Over 180
ALASKA
INSUFFICIENT DATA FOR ISOLINES
ARCTIC CIRCLE
AREAS TOO UNCERTAIN FOR SHADING
HAWAII
AREAS TOO SMALL FOR ISOLINES AND SHADING
PUERTO RICO AND VIRGIN ISLANDS
San Juan
Ponce
212
Alex. Hamilton Fld.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GULF OF MEXICO
International Falls
Duluth
S. Ste. Marie
Caribou
Burlington
Williston
Bismarck
Fargo
Minneapolis
Rapid City
Huron
Havre
Great Falls
Missoula
Billings
Spokane
Portland
Winnemucca
Salt Lake
Sacramento
San Francisco
Fresno
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
El Paso
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Springfield
Indianapolis
Columbus
Detroit
Lansing
Green Bay
Buffalo
Pittsburgh
Harrisburg
Philadelphia
New York
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Charleston
Columbia
Atlanta
Knoxville
Nashville
Lexington
Charleston
St. Louis
Kansas City
Dodge City
Amarillo
Oklahoma City
Little Rock
Memphis
Birmingham
Jackson
Shreveport
Abilene
Fort Worth
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
Barrow
Barter Is.
Kotzebue
Nome
Fairbanks
Northway
McGrath
Bethel
Seward
Yakutat
Kodiak
Sitka
Juneau
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
Lihue
Honolulu
Kahului
Hilo
73
99
113
68
101
100
90
120
131
138
150
145
180
202
210
211
263
240
206
284

MEAN ANNUAL NUMBER OF DAYS WITH 0.01 INCH OR MORE OF PRECIPITATION

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.

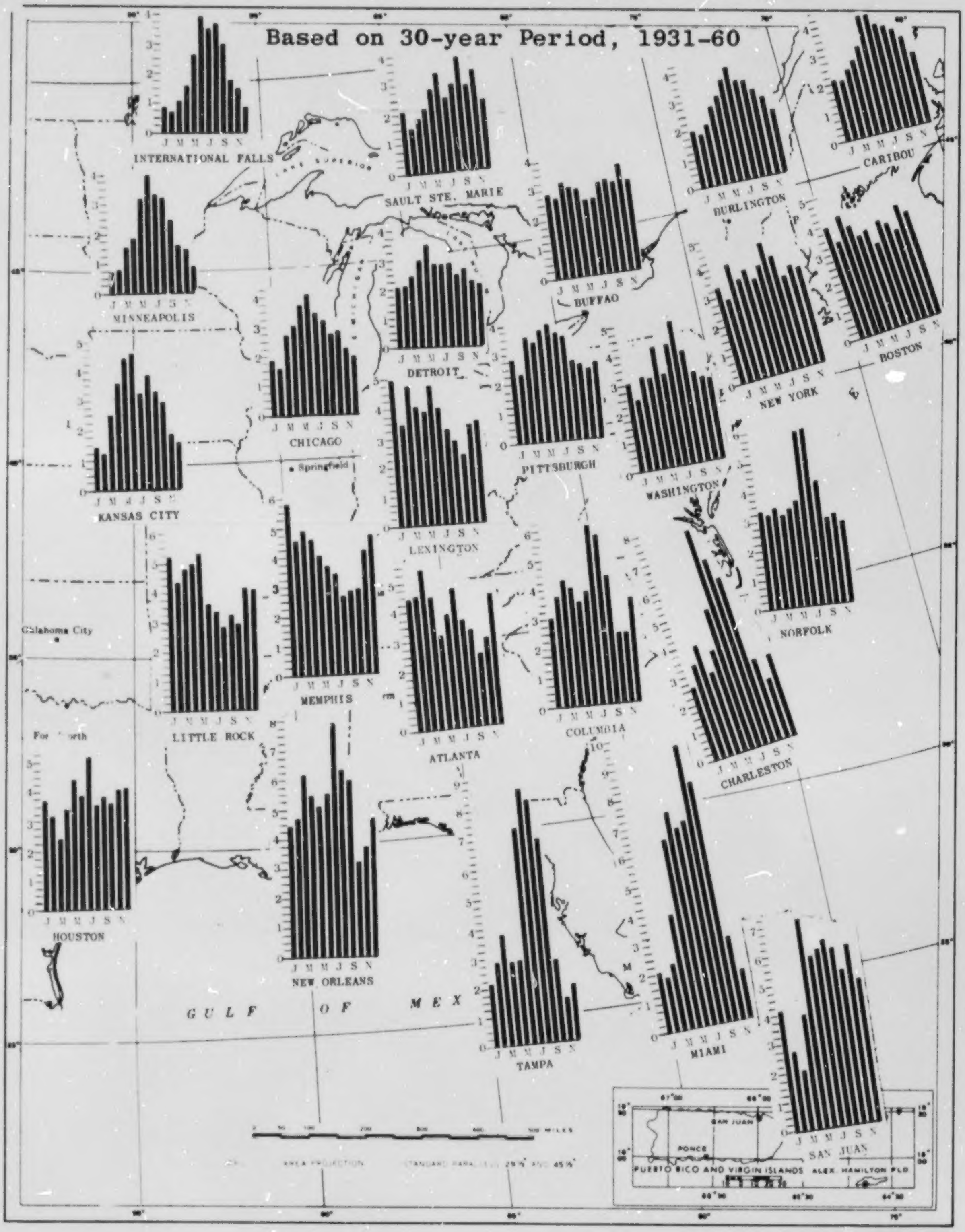
BASED ON PERIOD OF RECORD THROUGH 1965

Normal Monthly Total Precipitation (Inches), Western United States


Based on 30-year Period, 1931-60
SEATTLE
SPOKANE
HAVRE
WILLISTON
FARGO
BURNS
BOISE
LANDER
RAPID CITY
HURON
SAN FRANCISCO
RENO
SALT LAKE CITY
GRAND JUNCTION
DENVER
DODGE CITY
LOS ANGELES
LAS VEGAS
YUMA
PHOENIX
ALBUQUERQUE
EL PASO
AMARILLO
OKLAHOMA CITY
FT. WORTH
DEL RIO
BROWNSVILLE
Missoula
Billings
Roseburg
ALASKA
Barrow
Nome
Fairbanks
Anchorage
Bethel
St. Paul Is.
Cold Bay
Yakutat
Juneau
Annette
HAWAII
Lihue
Honolulu
Hilo
J M M J S N

Map 22

Normal Monthly Total Precipitation (Inches), Eastern United States



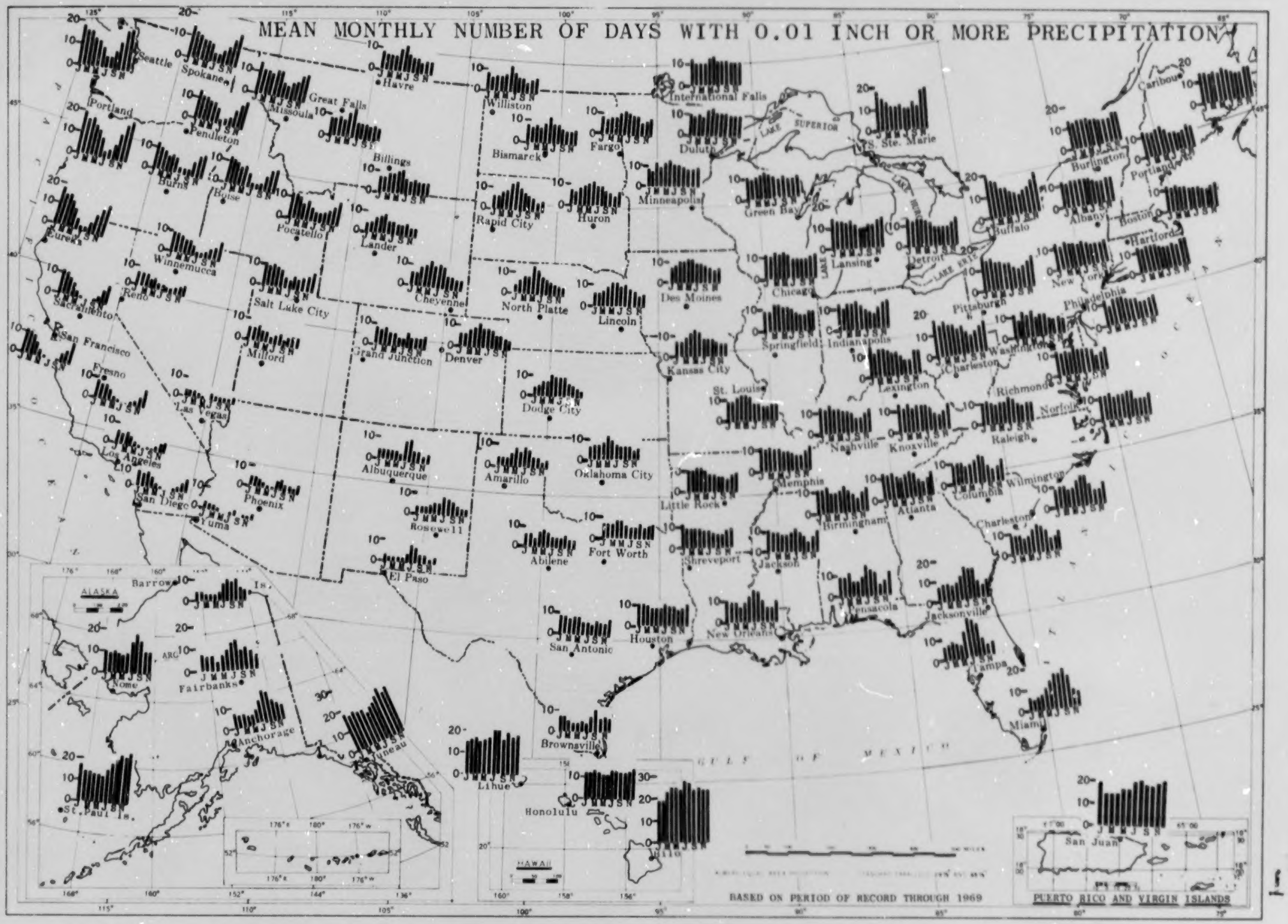
Based on 30-year Period, 1931-60

INTERNATIONAL FALLS
SAULT STE. MARIE
BURLINGTON
CARIBOU
MINNEAPOLIS
DETROIT
BUFFAO
NEW YORK
BOSTON
CHICAGO
KANSAS CITY
PITTSBURGH
WASHINGTON
LEXINGTON
NORFOLK
LITTLE ROCK
MEMPHIS
ATLANTA
COLUMBIA
CHARLESTON
HOUSTON
NEW ORLEANS
TAMPA
MIAMI
SAN JUAN
J M M J S N
LAKE SUPERIOR
Springfield
Oklahoma City
Fort Worth
GULF OF MEX
PUERTO RICO AND VIRGIN ISLANDS
PONCE
SAN JUAN
ALEX. HAMILTON FLD.
AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES

Map 23

Map 24

MEAN MONTHLY NUMBER OF DAYS WITH 0.01 INCH OR MORE PRECIPITATION


0
10
20
30
J M M J S N
Seattle
Spokane
Havre
Williston
International Falls
Caribou
Portland
Great Falls
Missoula
Pendleton
Billings
Bismarck
Fargo
Duluth
Lake Superior
S. Ste. Marie
Burlington
Portland
Burns
Boise
Pocatello
Rapid City
Huron
Minneapolis
Green Bay
Lake Huron
Buffalo
Albany
Boston
Eureka
Winnemucca
Lander
Hartford
Lansing
Detroit
Lake Erie
Reno
Salt Lake City
Cheyenne
North Platte
Lincoln
Des Moines
Chicago
Pittsburgh
New York
Philadelphia
Sacramento
San Francisco
Grand Junction
Denver
Springfield
Indianapolis
Washington
Charleston
Lexington
Kansas City
Milford
Fresno
Las Vegas
St. Louis
Richmond
Norfolk
Dodge City
Nashville
Knoxville
Raleigh
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Little Rock
Wilmington
Columbia
Atlanta
Birmingham
San Diego
Phoenix
Yuma
Roswell
Abilene
Fort Worth
Shreveport
Jackson
Charleston
El Paso
Pensacola
Jacksonville
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
ALASKA
Barrow
Nome
Fairbanks
Anchorage
Juneau
St. Paul Is.
Lihue
Honolulu
Hilo
HAWAII
San Juan
PUERTO RICO AND VIRGIN ISLANDS

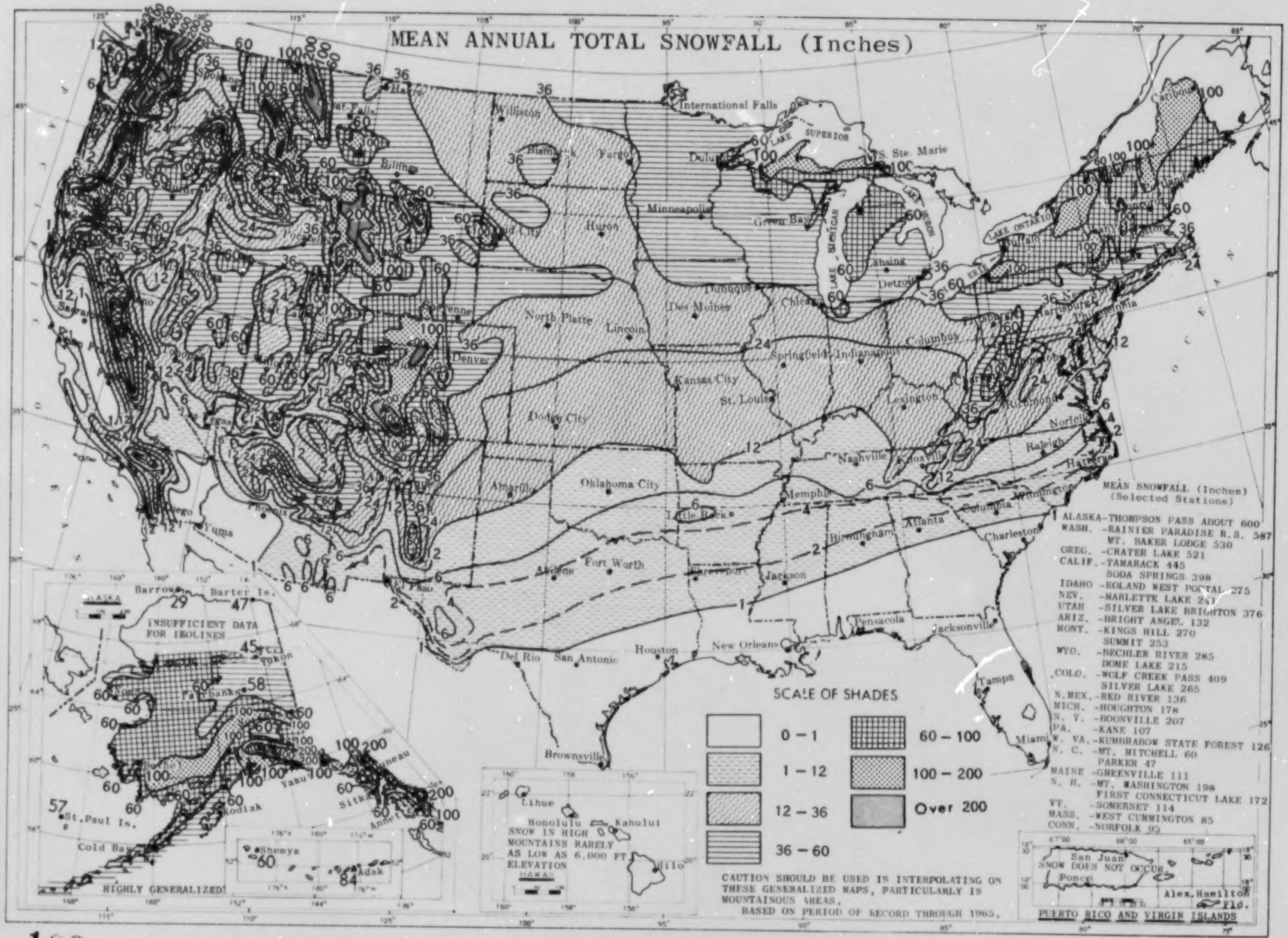
BASED ON PERIOD OF RECORD THROUGH 1969

101

102

Map 25

MEAN ANNUAL TOTAL SNOWFALL (Inches)


International Falls
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
ERIE
Williston
Bismarck
Fargo
Duluth
S. Ste. Marie
Caribou
Minneapolis
Green Bay
Huron
Rapid City
Havre
Great Falls
Billings
Spokane
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
Buffalo
Harrisburg
Philadelphia
Cheyenne
Denver
Kansas City
Springfield
Indianapolis
Columbus
Pittsburgh
St. Louis
Lexington
Richmond
Norfolk
Dodge City
Nashville
Knoxville
Raleigh
Hatteras
Amarillo
Oklahoma City
Memphis
Little Rock
Atlanta
Columbia
Wilmington
Birmingham
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
Las Vegas
Phoenix
Yuma
San Diego
Sacramento
Reno
ALASKA
Barrow 29
Barter Is. 47
INSUFFICIENT DATA FOR ISOLINES
Fairbanks 58
Yukon 45
Bethel
Yakutat
Juneau
Sitka
Annette
Kodiak
Cold Bay
St. Paul Is. 57
Shemya 60
Adak 84
HIGHLY GENERALIZED
HAWAII
Lihue
Honolulu
Kahului
Hilo
SNOW IN HIGH MOUNTAINS RARELY AS LOW AS 6,000 FT. ELEVATION
San Juan
SNOW DOES NOT OCCUR
Ponce
Alex.Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

MEAN SNOWFALL (Inches)
(Selected Stations)

ALASKA-THOMPSON PASS ABOUT 600
WASH. -RAINIER PARADISE R.S. 587
MT. BAKER LODGE 530
OREG. -CRATER LAKE 521
CALIF.-TAMARACK 445
SODA SPRINGS 398
IDAHO -ROLAND WEST PORTAL 275
NEV. -MARLETTE LAKE 241
UTAH -SILVER LAKE BRIGHTON 376
ARIZ. -BRIGHT ANGEL 132
MONT. -KINGS HILL 270
SUMMIT 253
WYO. -BECHLER RIVER 285
DOME LAKE 215
COLO. -WOLF CREEK PASS 409
SILVER LAKE 265
N.MEX.-RED RIVER 136
MICH. -HOUGHTON 178
N. Y. -BOONVILLE 207
PA. -KANE 107
W. VA.-KUMBRABOW STATE FOREST 126
N. C. -MT. MITCHELL 60
PARKER 47
MAINE -GREENVILLE 111
N. H. -MT. WASHINGTON 198
FIRST CONNECTICUT LAKE 172
VT. -SOMERSET 114
MASS. -WEST CUMMINGTON 85
CONN. -NORFOLK 93

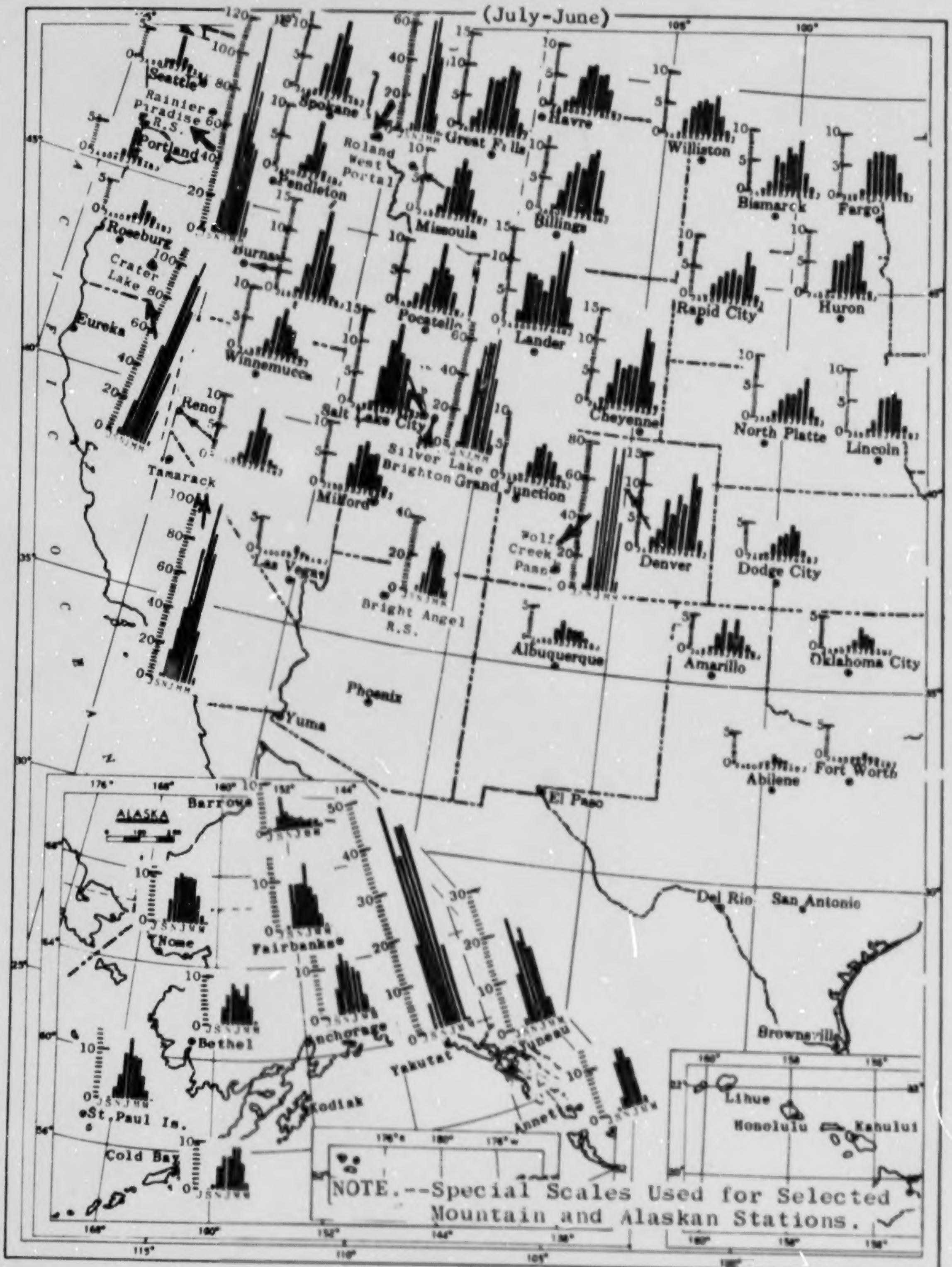
SCALE OF SHADES

☐	0 – 1	▦	60 – 100
░	1 – 12	▒	100 – 200
▨	12 – 36	▓	Over 200
▤	36 – 60		

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS.

BASED ON PERIOD OF RECORD THROUGH 1965.

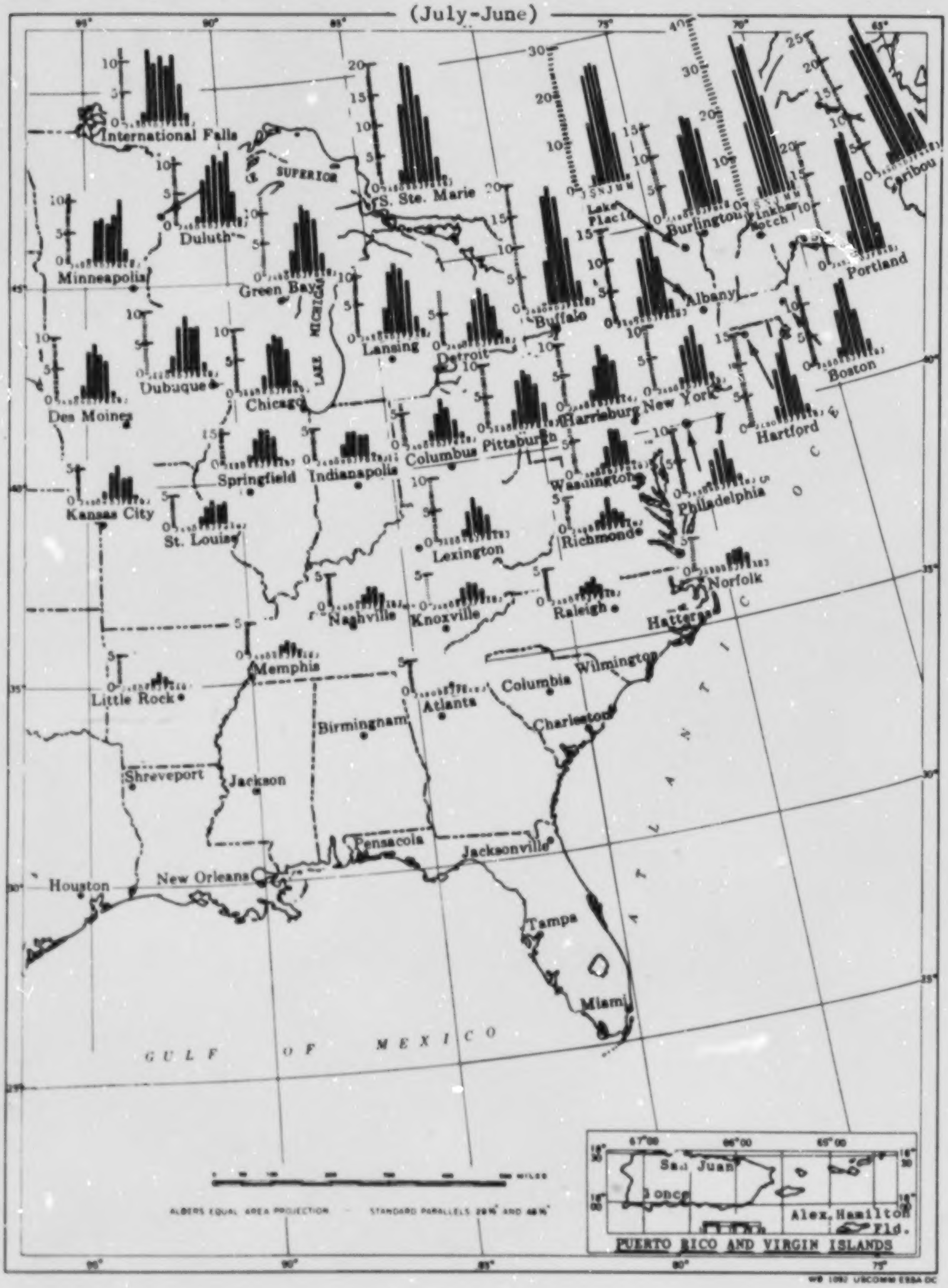
Mean Monthly Snowfall (Inches) for Selected Stations Western United States


(July-June)
Seattle
Rainier Paradise R.S.
Portland
Roseburg
Crater Lake
Eureka
Spokane
Pendleton
Burns
Winnemucca
Reno
Tamarack
Las Vegas
Roland West Portal
Great Falls
Missoula
Pocatello
Salt Lake City
Silver Lake Brighton
Milford
Bright Angel R.S.
Havre
Billings
Lander
Grand Junction
Wolf Creek Pass
Williston
Cheyenne
Denver
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Albuquerque
Amarillo
Oklahoma City
Phoenix
Yuma
El Paso
Abilene
Fort Worth
Del Rio
San Antonio
Brownsville
ALASKA
Barrow
Nome
Fairbanks
Bethel
Anchorage
St. Paul Is.
Kodiak
Cold Bay
Yakutat
Juneau
Annette
Lihue
Honolulu
Kahului
P A C I F I C   O C E A N
NOTE.--Special Scales Used for Selected Mountain and Alaskan Stations.

Map 26

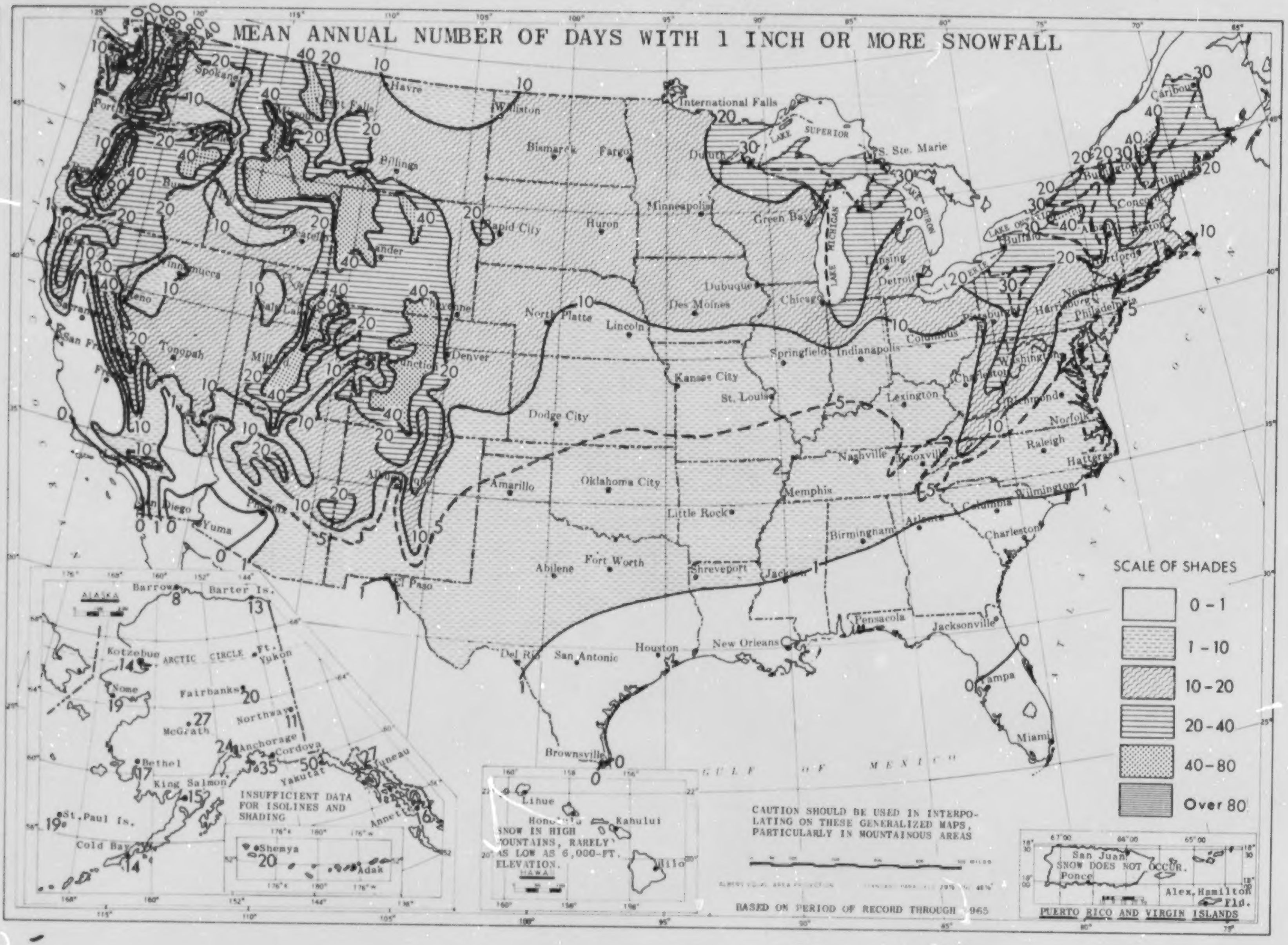
Mean Monthly Snowfall (Inches) for Selected Stations Eastern United States

(July-June)


International Falls
Duluth
Minneapolis
SUPERIOR
S. Ste. Marie
Green Bay
LAKE MICHIGAN
Lake Placid
Burlington
Pinkham Notch
Caribou
Portland
Buffalo
Albany
Boston
Lansing
Detroit
Des Moines
Dubuque
Chicago
Harrisburg
New York
Hartford
Pittsburgh
Columbus
Springfield
Indianapolis
Washington
Philadelphia
Kansas City
St. Louis
Lexington
Richmond
Norfolk
Nashville
Knoxville
Raleigh
Hatteras
Memphis
Little Rock
Wilmington
Columbia
Atlanta
Charleston
Birmingham
Shreveport
Jackson
Pensacola
Jacksonville
Houston
New Orleans
Tampa
Miami
GULF OF MEXICO
ATLANTIC OCEAN
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
WB 1092 USCOMM ESSA DC

Map 27

Map 28



MEAN ANNUAL NUMBER OF DAYS WITH 1 INCH OR MORE SNOWFALL

SCALE OF SHADES

☐	0 - 1
░	1 - 10
▨	10 - 20
▤	20 - 40
▒	40 - 80
▩	Over 80

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS

BASED ON PERIOD OF RECORD THROUGH 1965

ALASKA — INSUFFICIENT DATA FOR ISOLINES AND SHADING

HAWAII — SNOW IN HIGH MOUNTAINS, RARELY AS LOW AS 6,000-FT. ELEVATION.

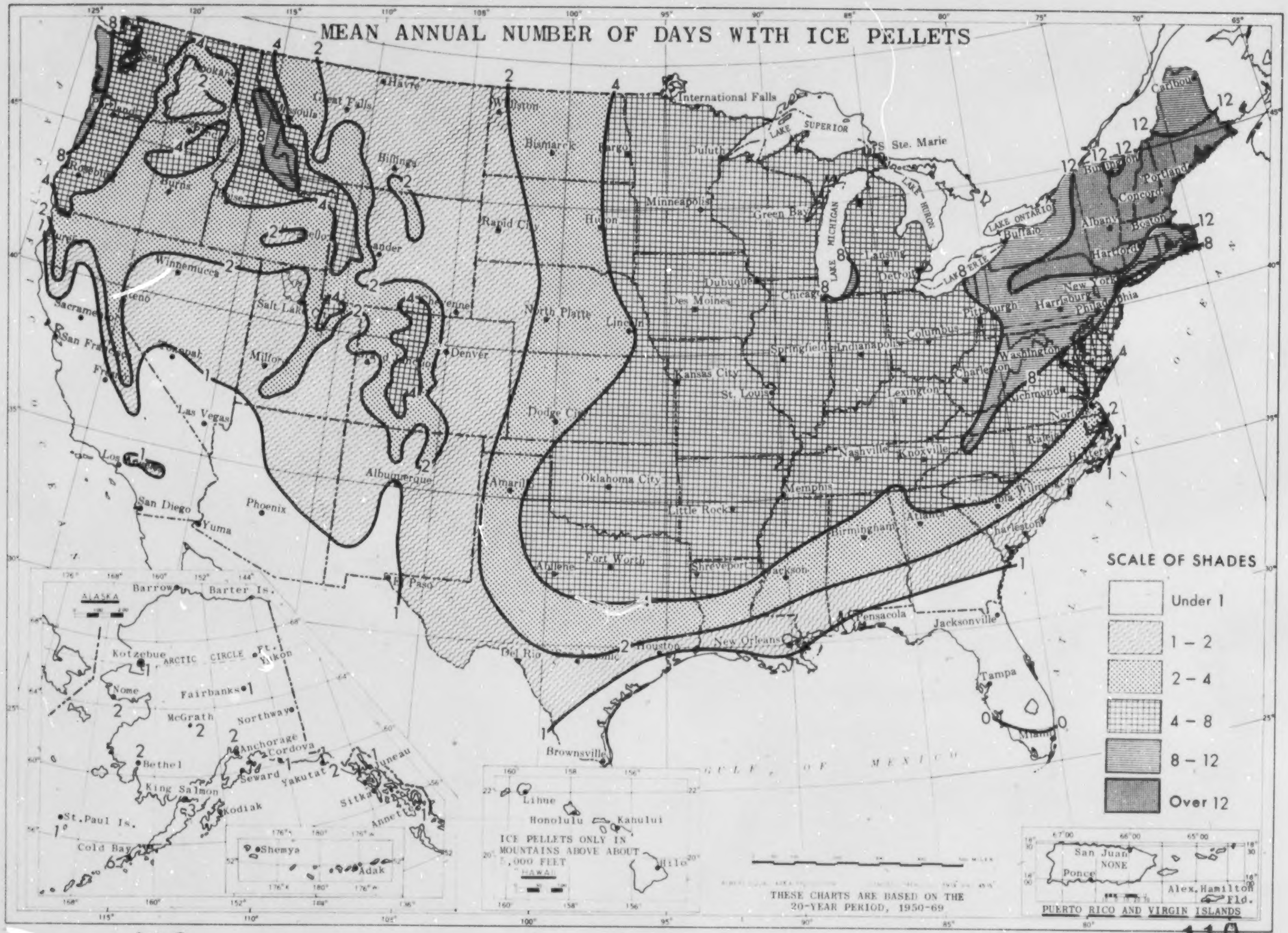
PUERTO RICO AND VIRGIN ISLANDS — SNOW DOES NOT OCCUR.

Spokane
Portland
Havre
Great Falls
Williston
International Falls
Bismarck
Fargo
Duluth
Lake Superior
S. Ste. Marie
Caribou
Billings
Boise
Rapid City
Huron
Minneapolis
Green Bay
Lake Michigan
Lake Huron
Burlington
Portland
Concord
Boston
Lake Ontario
Buffalo
Hartford
Pocatello
Lander
Winnemucca
Reno
Salt Lake City
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
Lake Erie
Pittsburgh
Harrisburg
New York
Philadelphia
San Francisco
Fresno
Tonopah
Milford
Grand Junction
Denver
Kansas City
Springfield
Indianapolis
Columbus
Washington
Charleston
St. Louis
Lexington
Richmond
Norfolk
Dodge City
Nashville
Knoxville
Raleigh
Hatteras
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Wilmington
San Diego
Yuma
Phoenix
Little Rock
Birmingham
Atlanta
Columbia
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
Barrow 8
Barter Is. 13
Kotzebue 14
ARCTIC CIRCLE
Ft. Yukon
Nome 19
Fairbanks 20
McGrath 27
Northway 11
Anchorage 24
Cordova
Bethel 17
King Salmon 15
35
50
Yakutat
Juneau 27
Annette 16
St. Paul Is. 19
Cold Bay 14
Shemya 20
Adak
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.

107

108

Map 29



MEAN ANNUAL NUMBER OF DAYS WITH ICE PELLETS

Seattle
Spokane
Portland
Roseburg
Burns
Reno
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Yuma
Phoenix
Las Vegas
Tonopah
Milford
Salt Lake
Winnemucca
Boise
Great Falls
Havre
Missoula
Billings
Lander
Cheyenne
Denver
Albuquerque
El Paso
Williston
Bismarck
Fargo
Huron
Rapid City
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Green Bay
Dubuque
Des Moines
Chicago
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Detroit
Lansing
Little Rock
Shreveport
Memphis
Nashville
Knoxville
Lexington
Charleston
Birmingham
Atlanta
Jackson
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Charleston
Wilmington
Raleigh
Norfolk
Hatteras
Richmond
Washington
Pittsburgh
Harrisburg
Philadelphia
New York
Hartford
Albany
Boston
Buffalo
Burlington
Concord
Portland
Caribou
Sault Ste. Marie
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GULF OF MEXICO
ALASKA
Barrow
Barter Is.
Kotzebue
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks
McGrath
Northway
Anchorage
Cordova
Bethel
Seward
Yakutat
Juneau
King Salmon
Kodiak
Sitka
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
Lihue
Honolulu
Kahului
Hilo
HAWAII
San Juan
Ponce
Alex. Hamilton Fld.

SCALE OF SHADES

☐	Under 1
▨	1 – 2
▨	2 – 4
▦	4 – 8
▩	8 – 12
■	Over 12

ICE PELLETS ONLY IN MOUNTAINS ABOVE ABOUT 5,000 FEET

San Juan NONE

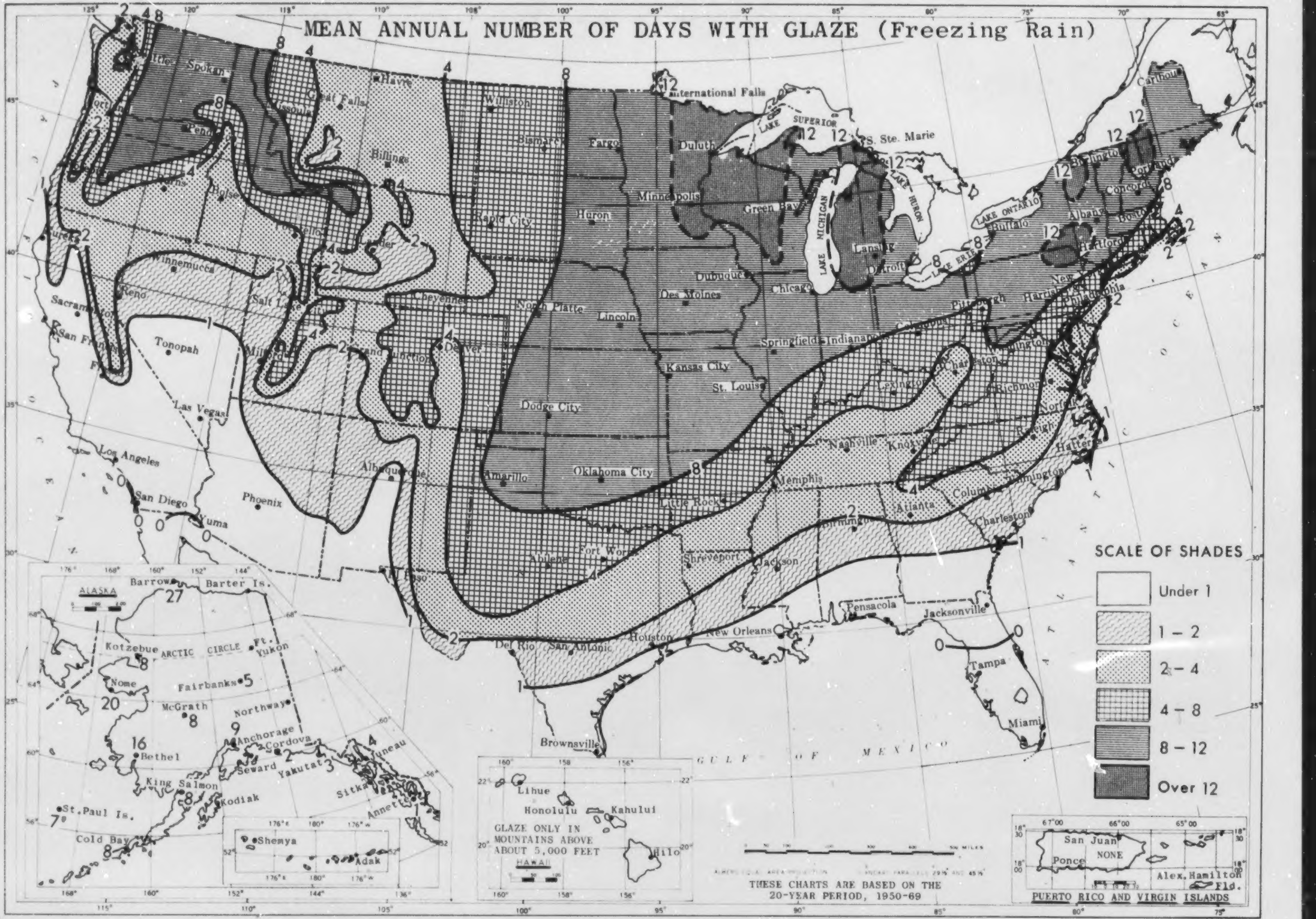
PUERTO RICO AND VIRGIN ISLANDS

THESE CHARTS ARE BASED ON THE 20-YEAR PERIOD, 1950-69

~~108~~ 109

Map 30

MEAN ANNUAL NUMBER OF DAYS WITH GLAZE (Freezing Rain)

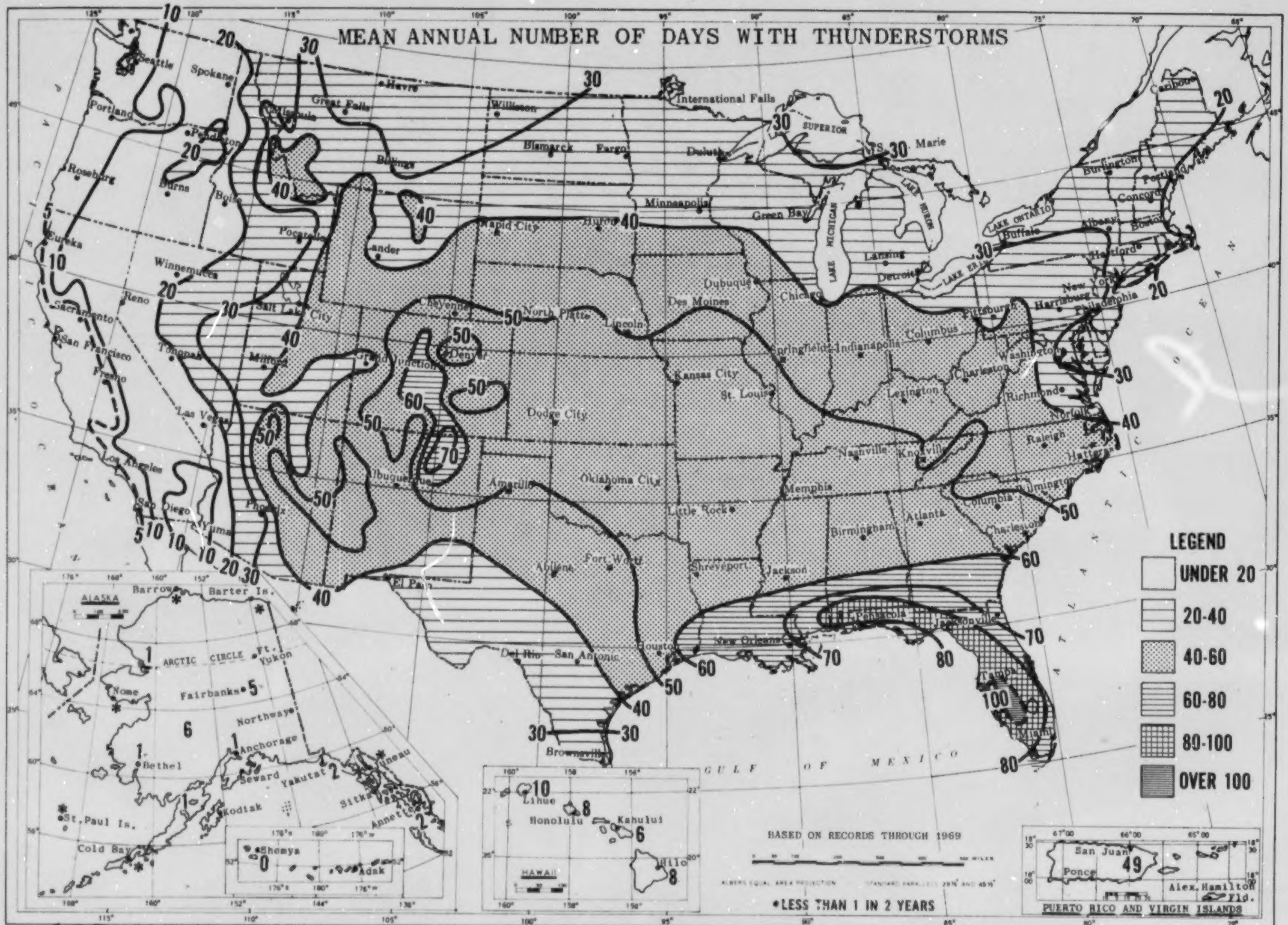


SCALE OF SHADES
Under 1
1 – 2
2 – 4
4 – 8
8 – 12
Over 12
Spokane
Havre
Great Falls
Billings
Williston
Bismarck
Fargo
International Falls
Duluth
LAKE SUPERIOR
S. Ste. Marie
Caribou
Burlington
Portland
Concord
Albany
Boston
Hartford
LAKE ONTARIO
Buffalo
LAKE HURON
LAKE MICHIGAN
Green Bay
Lansing
Detroit
LAKE ERIE
Minneapolis
Huron
Rapid City
Dubuque
Des Moines
Chicago
Pittsburgh
Harrisburg
New York
Philadelphia
Reno
Winnemucca
Sacramento
San Francisco
Salt Lake
Cheyenne
North Platte
Lincoln
Denver
Grand Junction
Springfield
Indianapolis
Kansas City
St. Louis
Charleston
Lexington
Washington
Richmond
Norfolk
Tonopah
Las Vegas
Dodge City
Nashville
Knoxville
Raleigh
Hatteras
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Wilmington
Columbia
Atlanta
San Diego
Phoenix
Yuma
Little Rock
Birmingham
Charleston
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
ATLANTIC OCEAN
ALASKA
Barrow
Barter Is.
Kotzebue
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks
McGrath
Northway
Anchorage
Cordova
Bethel
Seward
Yakutat
Juneau
King Salmon
Kodiak
Sitka
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
Lihue
Honolulu
Kahului
Hilo
GLAZE ONLY IN MOUNTAINS ABOVE ABOUT 5,000 FEET
HAWAII
San Juan
Ponce
NONE
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

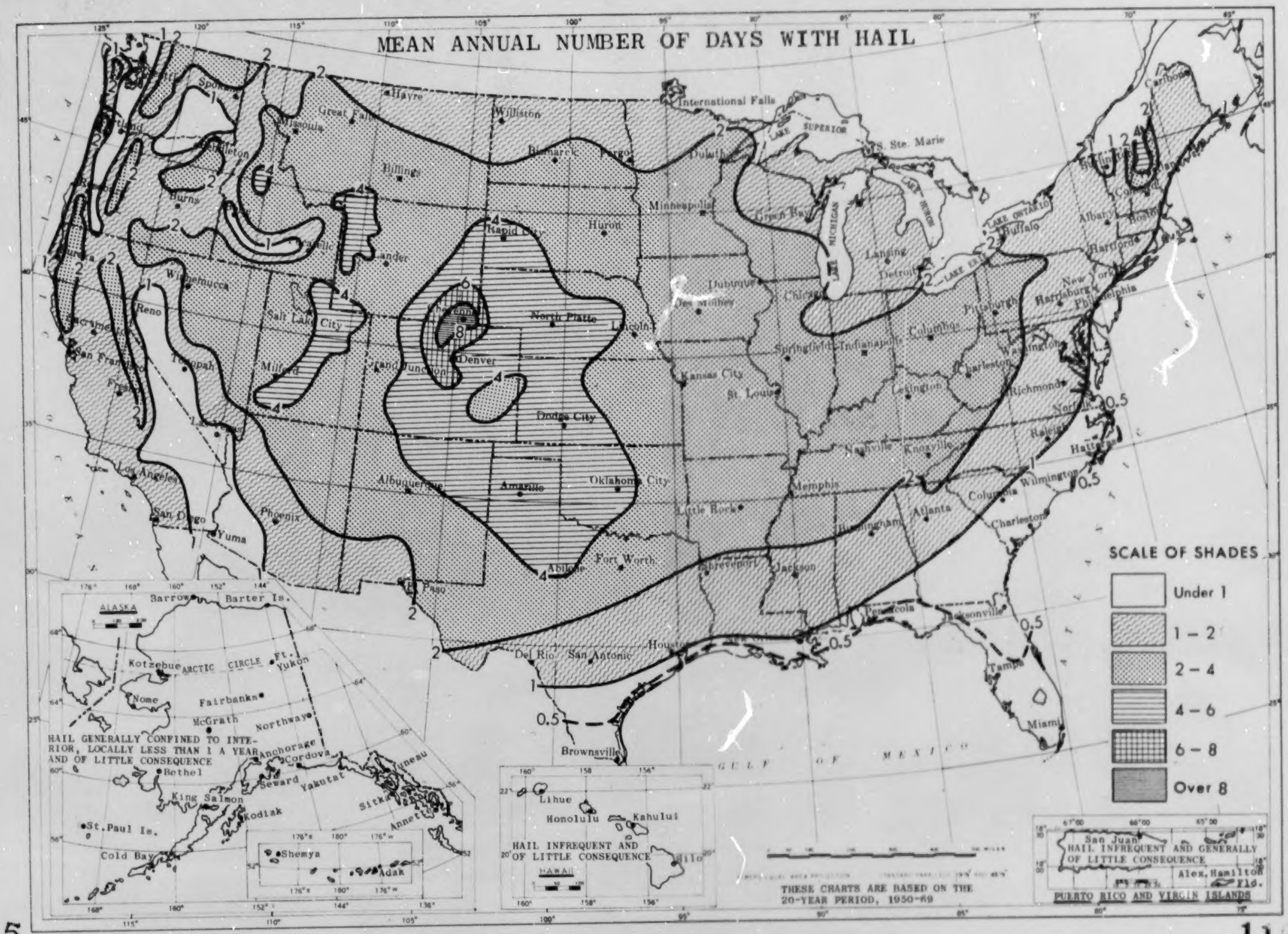
THESE CHARTS ARE BASED ON THE 20-YEAR PERIOD, 1950-69

Map 31

MEAN ANNUAL NUMBER OF DAYS WITH THUNDERSTORMS


LEGEND
UNDER 20
20-40
40-60
60-80
80-100
OVER 100
BASED ON RECORDS THROUGH 1969
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
*LESS THAN 1 IN 2 YEARS
ALASKA
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks 5
6
Northway
Bethel
Anchorage
Seward
Yakutat
Juneau
Kodiak
Sitka
Annette
St. Paul Is.
Cold Bay
Shemya 0
Adak
HAWAII
Lihue 10
Honolulu 8
Kahului
6
Hilo 8
PUERTO RICO AND VIRGIN ISLANDS
San Juan
Ponce
49
Alex. Hamilton Fld.
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Seattle
Spokane
Havre
Great Falls
Williston
International Falls
Portland
Pendleton
Missoula
Billings
Bismarck
Fargo
Duluth
Sault Ste. Marie
Caribou
Roseburg
Burns
Boise
Minneapolis
Green Bay
Burlington
Portland
Concord
Eureka
Pocatello
Lander
Rapid City
Huron
Albany
Boston
Winnemucca
Hartford
Reno
Salt Lake City
Cheyenne
North Platte
Dubuque
Des Moines
Chicago
Lansing
Detroit
Buffalo
New York
Sacramento
San Francisco
Tonopah
Grand Junction
Denver
Lincoln
Pittsburgh
Harrisburg
Philadelphia
Fresno
Milford
Kansas City
Springfield
Indianapolis
Columbus
Washington
St. Louis
Charleston
Lexington
Richmond
Las Vegas
Dodge City
Norfolk
Los Angeles
Nashville
Knoxville
Raleigh
Hatteras
Albuquerque
Amarillo
Oklahoma City
Memphis
San Diego
Phoenix
Little Rock
Wilmington
Yuma
Birmingham
Atlanta
Columbia
Charleston
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
10
20
30
40
50
60
70
80
100
5

Map 32



MEAN ANNUAL NUMBER OF DAYS WITH HAIL

HAIL GENERALLY CONFINED TO INTERIOR, LOCALLY LESS THAN 1 A YEAR AND OF LITTLE CONSEQUENCE

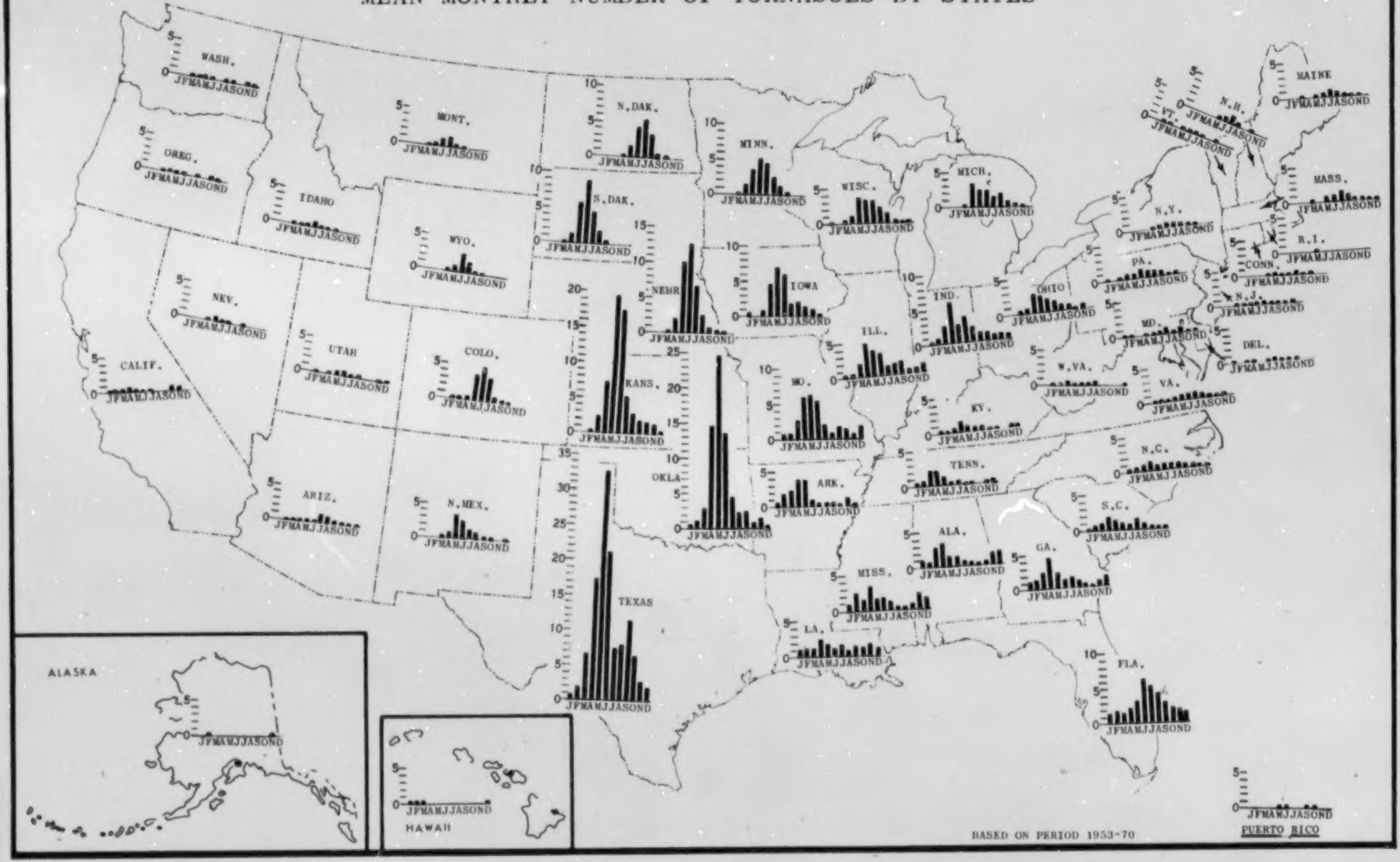
HAIL INFREQUENT AND OF LITTLE CONSEQUENCE

HAIL INFREQUENT AND GENERALLY OF LITTLE CONSEQUENCE

THESE CHARTS ARE BASED ON THE 20-YEAR PERIOD, 1950-69

SCALE OF SHADES
Under 1
1 – 2
2 – 4
4 – 6
6 – 8
Over 8
0.5
1
2
4
6
8
Spokane
Portland
Pendleton
Burns
Reno
Winnemucca
Sacramento
San Francisco
Fresno
Tonopah
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Missoula
Great Falls
Havre
Billings
Pocatello
Lander
Salt Lake City
Milford
Grand Junction
Cheyenne
Denver
Albuquerque
El Paso
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Des Moines
Dubuque
Kansas City
St. Louis
Little Rock
Shreveport
Jackson
Memphis
Nashville
Knoxville
Lexington
Springfield
Indianapolis
Chicago
Green Bay
Lansing
Detroit
Columbus
Pittsburgh
Charleston
Buffalo
Albany
Hartford
Boston
Concord
Caribou
Harrisburg
New York
Philadelphia
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Pensacola
Jacksonville
Tampa
Miami
S. Ste. Marie
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
GULF OF MEXICO
ALASKA
Barrow
Barter Is.
Kotzebue
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks
McGrath
Northway
Anchorage
Cordova
Bethel
King Salmon
Seward
Yakutat
Juneau
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
San Juan
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

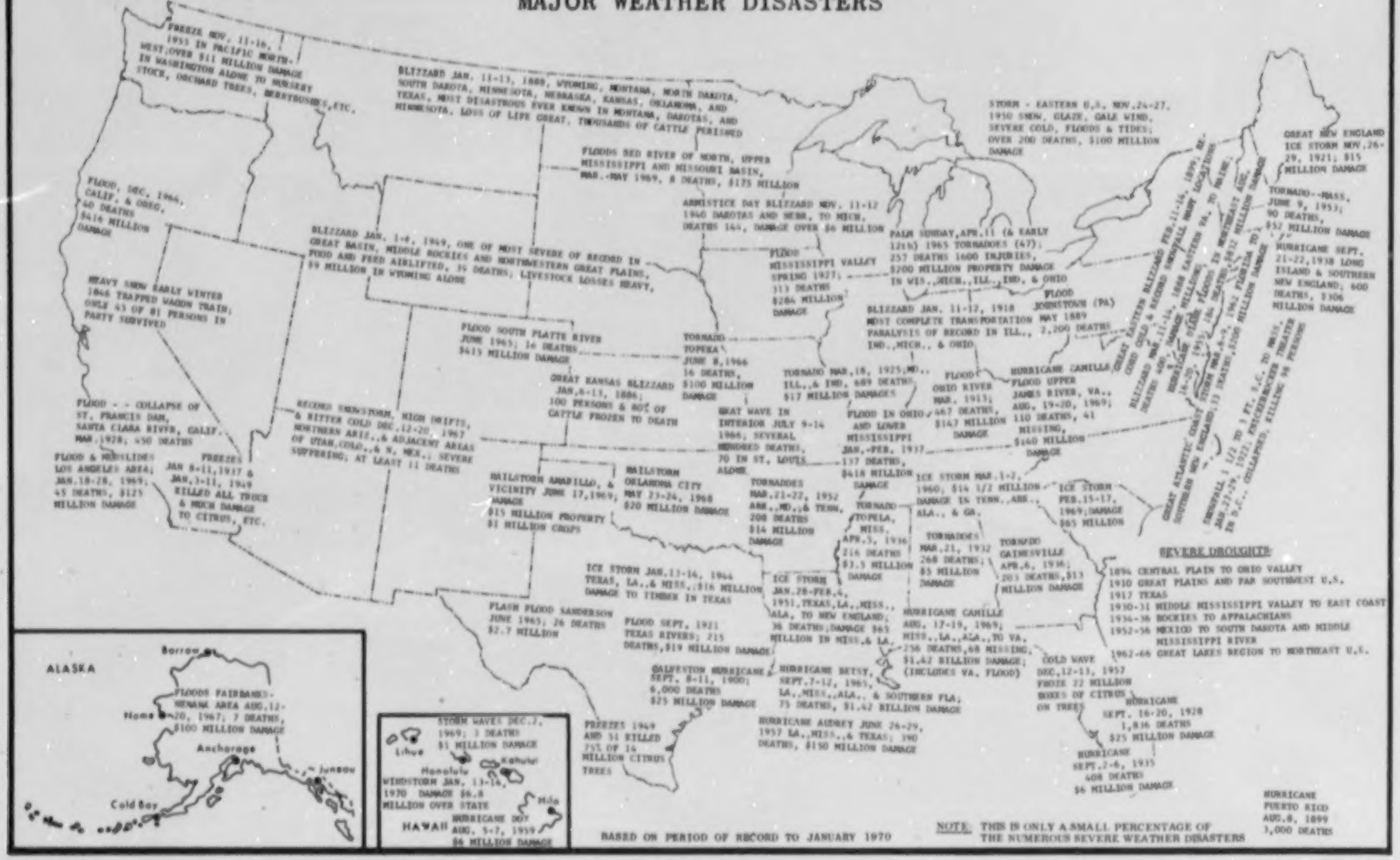
MEAN MONTHLY NUMBER OF TORNADOES BY STATES


WASH.
OREG.
CALIF.
NEV.
IDAHO
MONT.
WYO.
UTAH
ARIZ.
COLO.
N.MEX.
N.DAK.
S.DAK.
NEBR.
KANS.
OKLA.
TEXAS
MINN.
IOWA
MO.
ARK.
LA.
WISC.
ILL.
MISS.
MICH.
IND.
KY.
TENN.
ALA.
OHIO
W.VA.
GA.
FLA.
PA.
N.Y.
VA.
N.C.
S.C.
MD.
DEL.
N.J.
CONN.
R.I.
MASS.
VT.
N.H.
MAINE
ALASKA
HAWAII
PUERTO RICO
JFMAMJJASOND
0
5
10
15
20
25
30
35

BASED ON PERIOD 1953-70

Map 34

MAJOR WEATHER DISASTERS

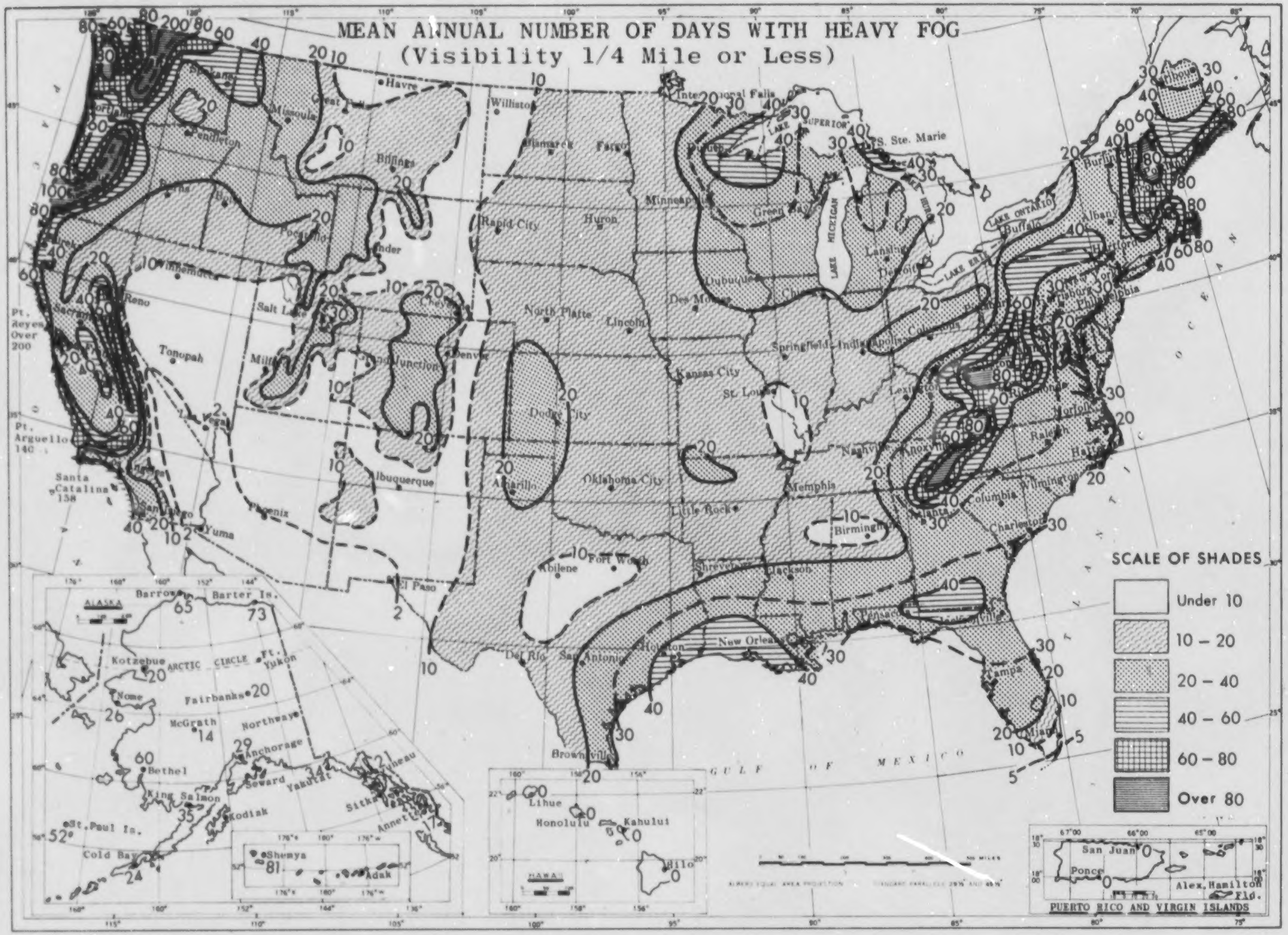

FREEZE NOV. 11-16, 1955 IN PACIFIC NORTHWEST;OVER $11 MILLION DAMAGE IN WASHINGTON ALONE TO NURSERY STOCK, ORCHARD TREES, BERRYBUSHES,ETC.
BLIZZARD JAN. 11-13, 1888, WYOMING, MONTANA, NORTH DAKOTA, SOUTH DAKOTA, MINNESOTA, NEBRASKA, KANSAS, OKLAHOMA, AND TEXAS, MOST DISASTROUS EVER KNOWN IN MONTANA, DAKOTAS, AND MINNESOTA. LOSS OF LIFE GREAT. THOUSANDS OF CATTLE PERISHED
FLOODS RED RIVER OF NORTH, UPPER MISSISSIPPI AND MISSOURI BASIN, MAR.-MAY 1969, 8 DEATHS, $175 MILLION
ARMISTICE DAY BLIZZARD NOV. 11-12 1940 DAKOTAS AND NEBR. TO MICH. DEATHS 144, DAMAGE OVER $6 MILLION
STORM - EASTERN U.S. NOV.24-27, 1950 SNOW, GLAZE, GALE WIND, SEVERE COLD, FLOODS & TIDES; OVER 200 DEATHS, $100 MILLION DAMAGE
GREAT NEW ENGLAND ICE STORM NOV.26-29, 1921; $15 MILLION DAMAGE
TORNADO--MASS. JUNE 9, 1953; 90 DEATHS, $52 MILLION DAMAGE
HURRICANE SEPT. 21-22,1938 LONG ISLAND & SOUTHERN NEW ENGLAND; 600 DEATHS, $306 MILLION DAMAGE
GREAT EASTERN BLIZZARD FEB.11-14, 1899; RECORD COLD & RECORD SNOWFALL MANY LOCATIONS
BLIZZARD MAR.11-14, 1888 EASTERN VA. TO MAINE; DEATHS 400; DAMAGE MILLIONS
HURRICANE DIANE FLOODS IN NORTHEAST AUG. 16-20, 1955; 184 DEATHS,$832 MILLION DAMAGE
GREAT ATLANTIC COAST STORM MAR.6-9, 1962 FLORIDA TO SOUTHERN NEW ENGLAND;33 DEATHS,$200 MILLION DAMAGE
SNOWFALL 1 1/2 TO 3 FT. S.C. TO MASS. JAN.27-29, 1922; KNICKERBOCKER THEATER IN D.C., COLLAPSED, KILLING 98 PERSONS
FLOOD, DEC. 1964, CALIF. & OREG. 40 DEATHS $416 MILLION DAMAGE
BLIZZARD JAN. 1-4, 1949, ONE OF MOST SEVERE OF RECORD IN GREAT BASIN, MIDDLE ROCKIES AND NORTHWESTERN GREAT PLAINS, FOOD AND FEED AIRLIFTED, 39 DEATHS; LIVESTOCK LOSSES HEAVY, $9 MILLION IN WYOMING ALONE
FLOOD MISSISSIPPI VALLEY SPRING 1927; 313 DEATHS $284 MILLION DAMAGE
PALM SUNDAY,APR.11 (& EARLY 12th) 1965 TORNADOES (47); 257 DEATHS 1600 INJURIES, $200 MILLION PROPERTY DAMAGE IN WIS.,MICH.,ILL.,IND., & OHIO
FLOOD JOHNSTOWN (PA) MAY 1889 2,200 DEATHS
HEAVY SNOW EARLY WINTER 1846 TRAPPED WAGON TRAIN; ONLY 45 OF 81 PERSONS IN PARTY SURVIVED
BLIZZARD JAN. 11-12, 1918 MOST COMPLETE TRANSPORTATION PARALYSIS OF RECORD IN ILL., IND.,MICH., & OHIO
FLOOD SOUTH PLATTE RIVER JUNE 1965; 16 DEATHS $415 MILLION DAMAGE
TORNADO TOPEKA JUNE 8,1966 16 DEATHS, $100 MILLION DAMAGE
GREAT KANSAS BLIZZARD JAN.6-13, 1886; 100 PERSONS & 80% OF CATTLE FROZEN TO DEATH
TORNADO MAR.18, 1925;MO., ILL.,& IND. 689 DEATHS $17 MILLION DAMAGES
FLOOD OHIO RIVER MAR. 1913; 467 DEATHS, $147 MILLION DAMAGE
HURRICANE CAMILLE FLOOD UPPER JAMES RIVER, VA., AUG. 19-20, 1969; 110 DEATHS, 41 MISSING, $140 MILLION DAMAGE
FLOOD - - COLLAPSE OF ST. FRANCIS DAM, SANTA CLARA RIVER, CALIF. MAR.1928; 450 DEATHS
RECORD SNOWSTORM, HIGH DRIFTS, & BITTER COLD DEC.12-20, 1967 NORTHERN ARIZ.,& ADJACENT AREAS OF UTAH,COLO.,& N. MEX.; SEVERE SUFFERING; AT LEAST 11 DEATHS
HEAT WAVE IN INTERIOR JULY 9-14 1966; SEVERAL HUNDRED DEATHS, 70 IN ST. LOUIS ALONE
FLOOD IN OHIO AND LOWER MISSISSIPPI JAN.-FEB. 1937 137 DEATHS, $418 MILLION DAMAGE
FLOOD & MUDSLIDES LOS ANGELES AREA; JAN.18-28, 1969, 45 DEATHS, $125 MILLION DAMAGE
FREEZES JAN 8-11,1937 & JAN.3-11, 1949 KILLED ALL TRUCK & MUCH DAMAGE TO CITRUS, ETC.
HAILSTORM AMARILLO, & VICINITY JUNE 17,1969; DAMAGE $15 MILLION PROPERTY $1 MILLION CROPS
HAILSTORM OKLAHOMA CITY MAY 23-24, 1968 $20 MILLION DAMAGE
TORNADOES MAR.21-22, 1952 ARK.,MO.,& TENN. 208 DEATHS $14 MILLION DAMAGE
ICE STORM MAR.1-2, 1960; $14 1/2 MILLION DAMAGE IN TENN.,ARK., ALA., & GA.
ICE STORM FEB.15-17, 1969;DAMAGE $65 MILLION
TORNADO TUPELO, MISS. APR.5, 1936 216 DEATHS $3.5 MILLION DAMAGE
TORNADOES MAR.21, 1932 268 DEATHS; $5 MILLION DAMAGE
TORNADO GAINESVILLE APR.6, 1936; 203 DEATHS,$13 MILLION DAMAGE
SEVERE DROUGHTS:
1894 CENTRAL PLAIN TO OHIO VALLEY
1910 GREAT PLAINS AND FAR SOUTHWEST U.S.
1917 TEXAS
1930-31 MIDDLE MISSISSIPPI VALLEY TO EAST COAST
1934-36 ROCKIES TO APPALACHIANS
1952-56 MEXICO TO SOUTH DAKOTA AND MIDDLE MISSISSIPPI RIVER
1962-66 GREAT LAKES REGION TO NORTHEAST U.S.
ICE STORM JAN.13-14, 1944 TEXAS, LA.,& MISS.;$16 MILLION DAMAGE TO TIMBER IN TEXAS
ICE STORM JAN.28-FEB.4, 1951,TEXAS,LA.,MISS., ALA. TO NEW ENGLAND; 36 DEATHS;DAMAGE $65 MILLION IN MISS.& LA.
FLASH FLOOD SANDERSON JUNE 1965; 26 DEATHS $2.7 MILLION
FLOOD SEPT. 1921 TEXAS RIVERS; 215 DEATHS,$19 MILLION DAMAGE
HURRICANE CAMILLE AUG. 17-19, 1969; MISS.,LA.,ALA.,TO VA. 256 DEATHS,68 MISSING, $1.42 BILLION DAMAGE; (INCLUDES VA. FLOOD)
GALVESTON HURRICANE SEPT. 8-11, 1900; 6,000 DEATHS $25 MILLION DAMAGE
HURRICANE BETSY, SEPT.7-12, 1965, LA.,MISS.,ALA., & SOUTHERN FLA; 75 DEATHS, $1.42 BILLION DAMAGE
COLD WAVE DEC.12-13, 1957 FROZE 22 MILLION BOXES OF CITRUS ON TREES
HURRICANE SEPT. 16-20, 1928 1,836 DEATHS $25 MILLION DAMAGE
FREEZES 1949 AND 51 KILLED 75% OF 14 MILLION CITRUS TREES
HURRICANE AUDREY JUNE 26-29, 1957 LA.,MISS.,& TEXAS; 390 DEATHS, $150 MILLION DAMAGE
HURRICANE SEPT.2-6, 1935 408 DEATHS $6 MILLION DAMAGE
ALASKA
Barrow
Nome
Anchorage
Cold Bay
Juneau
FLOODS FAIRBANKS-NENANA AREA AUG.12-20, 1967; 7 DEATHS, $100 MILLION DAMAGE
HAWAII
Lihue
Honolulu
Kahului
Hilo
TIDEW WAVES DEC.2, 1969; 3 DEATHS $1 MILLION DAMAGE
WINDSTORM JAN. 13-14, 1970 DAMAGE $6.8 MILLION OVER STATE
HURRICANE DOT AUG. 5-7, 1959 $6 MILLION DAMAGE
HURRICANE PUERTO RICO AUG.8, 1899 3,000 DEATHS

BASED ON PERIOD OF RECORD TO JANUARY 1970

NOTE: THIS IS ONLY A SMALL PERCENTAGE OF THE NUMEROUS SEVERE WEATHER DISASTERS

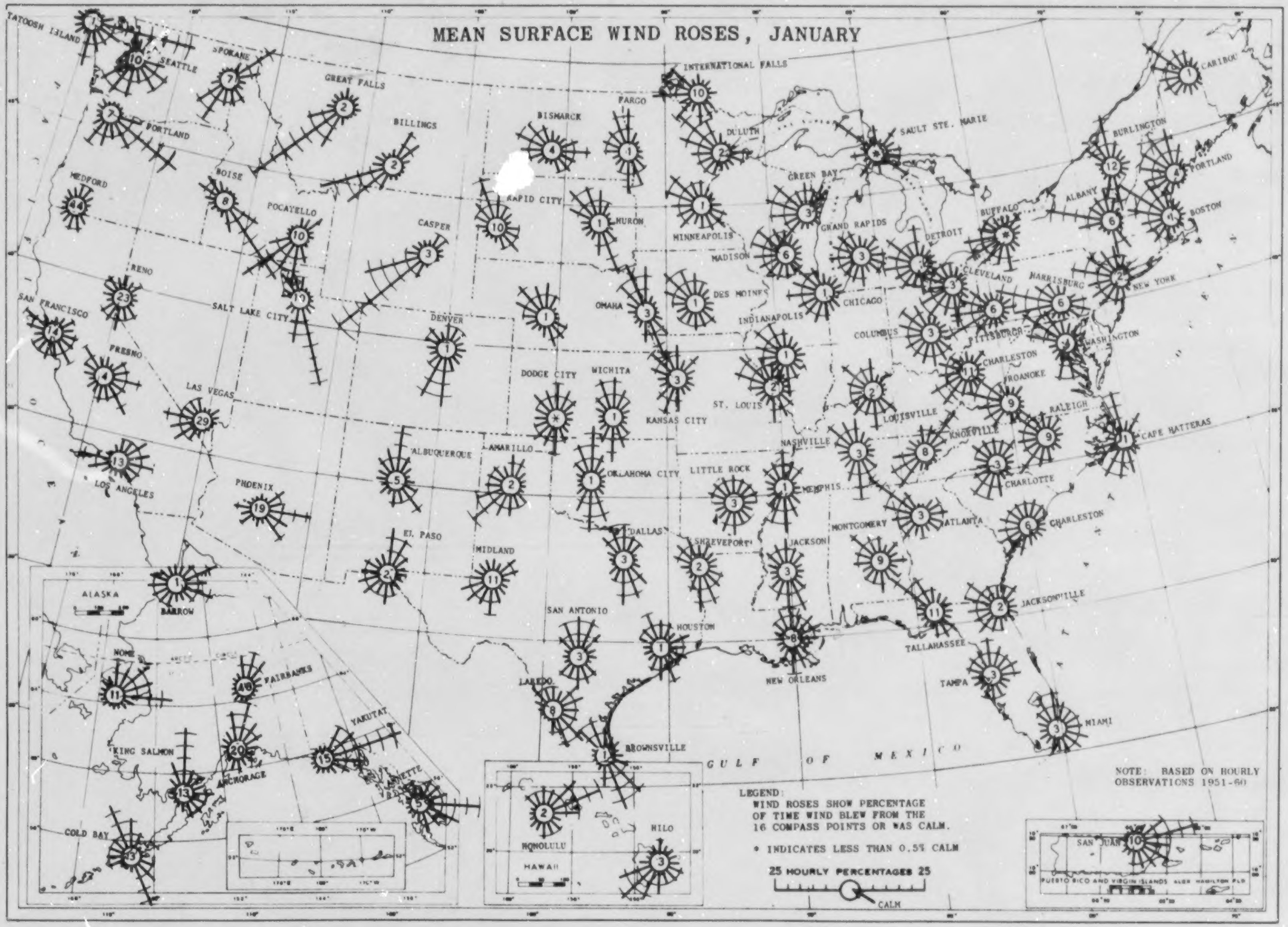
Map 35

MEAN ANNUAL NUMBER OF DAYS WITH HEAVY FOG
(Visibility 1/4 Mile or Less)


SCALE OF SHADES
Under 10
10 – 20
20 – 40
40 – 60
60 – 80
Over 80
Pt. Reyes Over 200
Pt. Arguello 140
Santa Catalina 138
Havre
Williston
Missoula
Billings
Pendleton
Bismarck
Fargo
Rapid City
Huron
Minneapolis
Green Bay
S. Ste. Marie
LAKE SUPERIOR
LAKE MICHIGAN
LAKE ONTARIO
LAKE ERIE
Burlington
Albany
Buffalo
Lansing
Detroit
Dubuque
Des Moines
Chicago
Winnemucca
Reno
Tonopah
Salt Lake
Cheyenne
Grand Junction
Denver
North Platte
Lincoln
Springfield
Indianapolis
Columbus
Philadelphia
Kansas City
St. Louis
Lexington
Dodge City
Las Vegas
Milford
Albuquerque
Amarillo
Oklahoma City
Nashville
Knoxville
Raleigh
Norfolk
Hatteras
Wilmington
Memphis
Little Rock
Birmingham
Atlanta
Columbia
Charleston
Phoenix
Yuma
San Diego
El Paso
Abilene
Fort Worth
Shreveport
Jackson
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Del Rio
San Antonio
Houston
Brownsville
GULF OF MEXICO
ATLANTIC OCEAN
ALASKA
Barrow 65
Barter Is. 73
Kotzebue 20
ARCTIC CIRCLE
Ft. Yukon
Nome 26
Fairbanks 20
McGrath 14
Northway
Anchorage 29
Bethel 60
King Salmon 35
Seward
Yakutat 34
Juneau 21
Sitka
Annette 17
Kodiak
St. Paul Is. 52
Cold Bay 24
Shemya 81
Adak
HAWAII
Lihue 0
Honolulu 0
Kahului 0
Hilo 0
San Juan 0
Ponce 0
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

Map 36

MEAN SURFACE WIND ROSES, JANUARY


TATOOSH ISLAND 7
SEATTLE 10
SPOKANE 7
GREAT FALLS 2
PORTLAND 7
BILLINGS 2
BISMARCK 4
FARGO 1
INTERNATIONAL FALLS 10
DULUTH 2
SAULT STE. MARIE *
CARIBOU 1
BURLINGTON 12
PORTLAND 4
BOSTON *
ALBANY 6
MEDFORD 44
BOISE 8
POCATELLO 10
RAPID CITY 10
HURON 1
MINNEAPOLIS 1
GREEN BAY 3
GRAND RAPIDS 3
DETROIT
BUFFALO *
CASPER 3
MADISON 6
RENO 23
SALT LAKE CITY 19
SAN FRANCISCO 14
DENVER 1
OMAHA 3
DES MOINES 1
CHICAGO 1
CLEVELAND 3
HARRISBURG 6
NEW YORK 2
INDIANAPOLIS 1
COLUMBUS 3
PITTSBURGH 6
WASHINGTON 4
FRESNO 4
DODGE CITY *
WICHITA 1
KANSAS CITY 3
ST. LOUIS 2
CHARLESTON 11
ROANOKE 9
LOUISVILLE 2
LAS VEGAS 29
RALEIGH 9
CAPE HATTERAS 1
NASHVILLE 3
KNOXVILLE 8
LOS ANGELES 13
ALBUQUERQUE 5
AMARILLO 2
OKLAHOMA CITY 1
LITTLE ROCK 3
MEMPHIS 1
CHARLOTTE 3
PHOENIX 19
ATLANTA 3
CHARLESTON 6
EL PASO 2
MIDLAND 11
DALLAS 3
SHREVEPORT 2
JACKSON 3
MONTGOMERY 9
SAN ANTONIO 3
HOUSTON 1
NEW ORLEANS 8
TALLAHASSEE 11
JACKSONVILLE 2
LAREDO 8
TAMPA 3
MIAMI 3
BROWNSVILLE 1
GULF OF MEXICO
ALASKA
BARROW 1
NOME 11
FAIRBANKS 48
KING SALMON
ANCHORAGE 20
YAKUTAT 15
ANNETTE 5
COLD BAY 3
13
HONOLULU 2
HAWAII
HILO 3
SAN JUAN 10
PUERTO RICO AND VIRGIN ISLANDS

LEGEND:
WIND ROSES SHOW PERCENTAGE
OF TIME WIND BLEW FROM THE
16 COMPASS POINTS OR WAS CALM.

* INDICATES LESS THAN 0.5% CALM

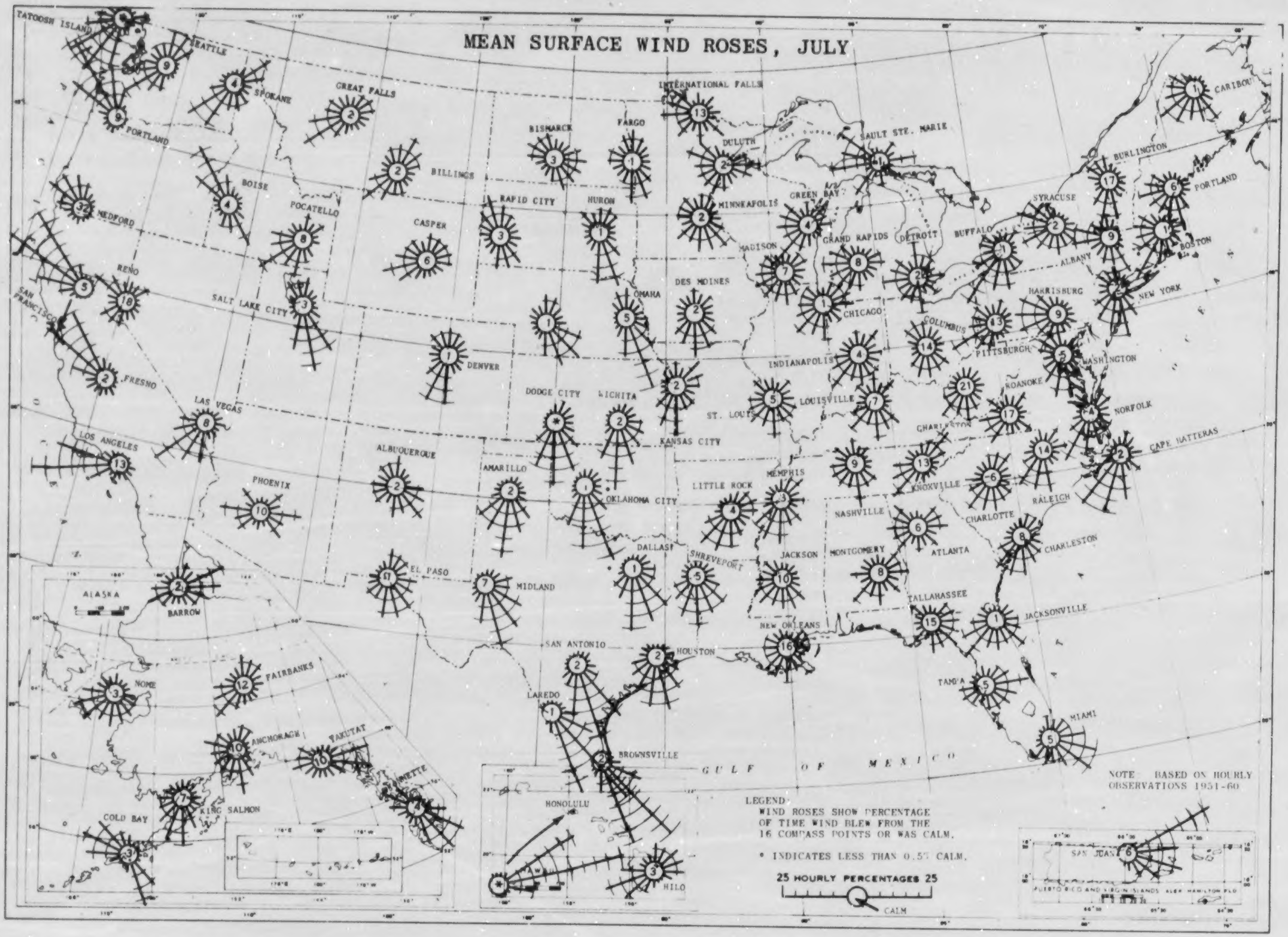
25 HOURLY PERCENTAGES 25

CALM

NOTE: BASED ON HOURLY
OBSERVATIONS 1951-60

Map 37

MEAN SURFACE WIND ROSES, JULY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SEATTLE
SPOKANE
GREAT FALLS
PORTLAND
BISMARCK
FARGO
INTERNATIONAL FALLS
DULUTH
SAULT STE. MARIE
CARIBOU
BILLINGS
BOISE
MEDFORD
POCATELLO
CASPER
RAPID CITY
HURON
MINNEAPOLIS
GREEN BAY
BURLINGTON
PORTLAND
SYRACUSE
BOSTON
ALBANY
BUFFALO
DETROIT
GRAND RAPIDS
MADISON
RENO
SAN FRANCISCO
SALT LAKE CITY
OMAHA
DES MOINES
CHICAGO
NEW YORK
HARRISBURG
COLUMBUS
PITTSBURGH
WASHINGTON
INDIANAPOLIS
DENVER
FRESNO
DODGE CITY
WICHITA
ST. LOUIS
KANSAS CITY
LOUISVILLE
ROANOKE
NORFOLK
CHARLESTON
LAS VEGAS
LOS ANGELES
ALBUQUERQUE
AMARILLO
OKLAHOMA CITY
LITTLE ROCK
MEMPHIS
NASHVILLE
KNOXVILLE
RALEIGH
CAPE HATTERAS
PHOENIX
CHARLOTTE
ATLANTA
CHARLESTON
DALLAS
SHREVEPORT
JACKSON
MONTGOMERY
EL PASO
MIDLAND
TALLAHASSEE
JACKSONVILLE
NEW ORLEANS
SAN ANTONIO
HOUSTON
TAMPA
MIAMI
LAREDO
BROWNSVILLE
GULF OF MEXICO
ALASKA
BARROW
NOME
FAIRBANKS
ANCHORAGE
YAKUTAT
ANNETTE
KING SALMON
COLD BAY
HONOLULU
HILO
SAN JUAN
PUERTO RICO AND VIRGIN ISLANDS

LEGEND:
WIND ROSES SHOW PERCENTAGE
OF TIME WIND BLEW FROM THE
16 COMPASS POINTS OR WAS CALM.

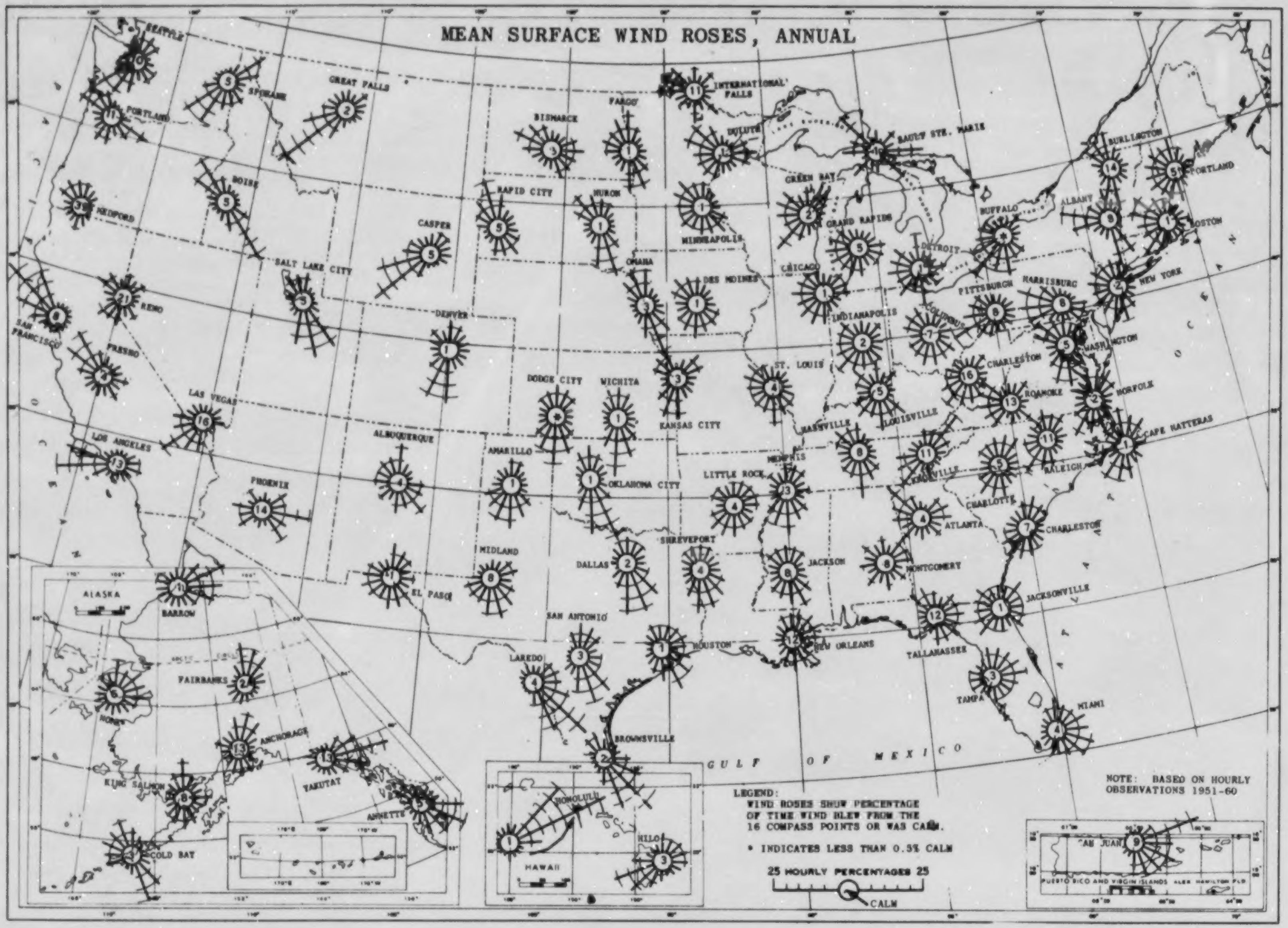
* INDICATES LESS THAN 0.5% CALM.

25 HOURLY PERCENTAGES 25

CALM

NOTE: BASED ON HOURLY
OBSERVATIONS 1951-60

MEAN SURFACE WIND ROSES, ANNUAL


SEATTLE
PORTLAND
SPOKANE
GREAT FALLS
MEDFORD
BOISE
CASPER
SALT LAKE CITY
RENO
SAN FRANCISCO
FRESNO
DENVER
LAS VEGAS
LOS ANGELES
PHOENIX
ALBUQUERQUE
EL PASO
BISMARCK
FARGO
INTERNATIONAL FALLS
DULUTH
RAPID CITY
HURON
MINNEAPOLIS
OMAHA
DES MOINES
DODGE CITY
WICHITA
KANSAS CITY
AMARILLO
OKLAHOMA CITY
MIDLAND
DALLAS
SAN ANTONIO
LAREDO
HOUSTON
BROWNSVILLE
SHREVEPORT
LITTLE ROCK
MEMPHIS
JACKSON
NEW ORLEANS
ST. LOUIS
GREEN BAY
SAULT STE. MARIE
GRAND RAPIDS
CHICAGO
DETROIT
INDIANAPOLIS
COLUMBUS
LOUISVILLE
NASHVILLE
KNOXVILLE
ATLANTA
MONTGOMERY
TALLAHASSEE
TAMPA
MIAMI
JACKSONVILLE
CHARLESTON
CHARLOTTE
RALEIGH
CAPE HATTERAS
NORFOLK
ROANOKE
CHARLESTON
PITTSBURGH
HARRISBURG
WASHINGTON
BUFFALO
ALBANY
NEW YORK
BOSTON
BURLINGTON
PORTLAND
O C E A N
G U L F   O F   M E X I C O
ALASKA
BARROW
FAIRBANKS
NOME
ANCHORAGE
YAKUTAT
KING SALMON
COLD BAT
ANNETTE
HAWAII
HONOLULU
HILO
SAN JUAN
PUERTO RICO AND VIRGIN ISLANDS
ALEX HAMILTON FLD

LEGEND:
WIND ROSES SHOW PERCENTAGE
OF TIME WIND BLEW FROM THE
16 COMPASS POINTS OR WAS CALM.

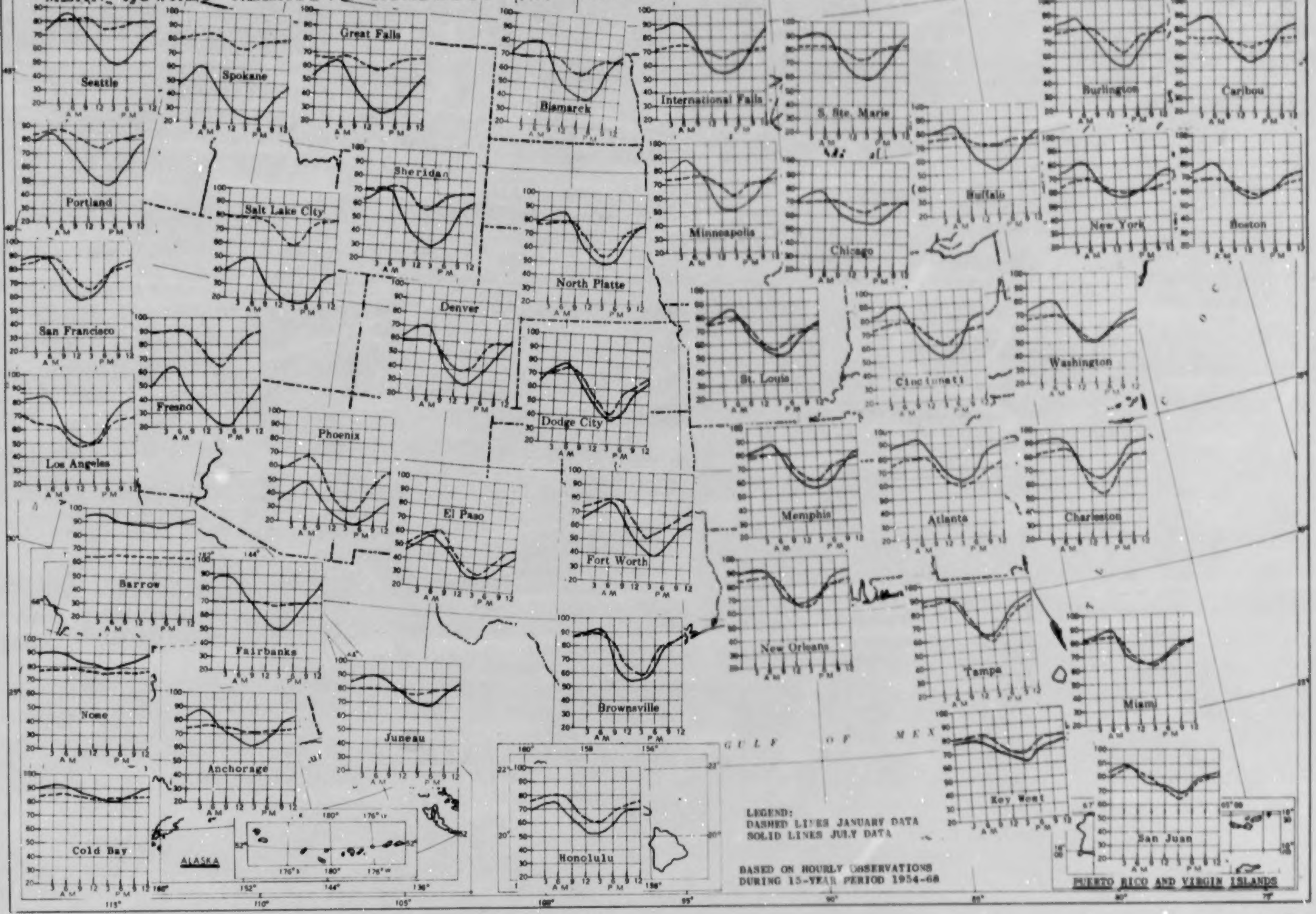
* INDICATES LESS THAN 0.5% CALM

25 HOURLY PERCENTAGES 25

CALM

NOTE: BASED ON HOURLY
OBSERVATIONS 1951-60

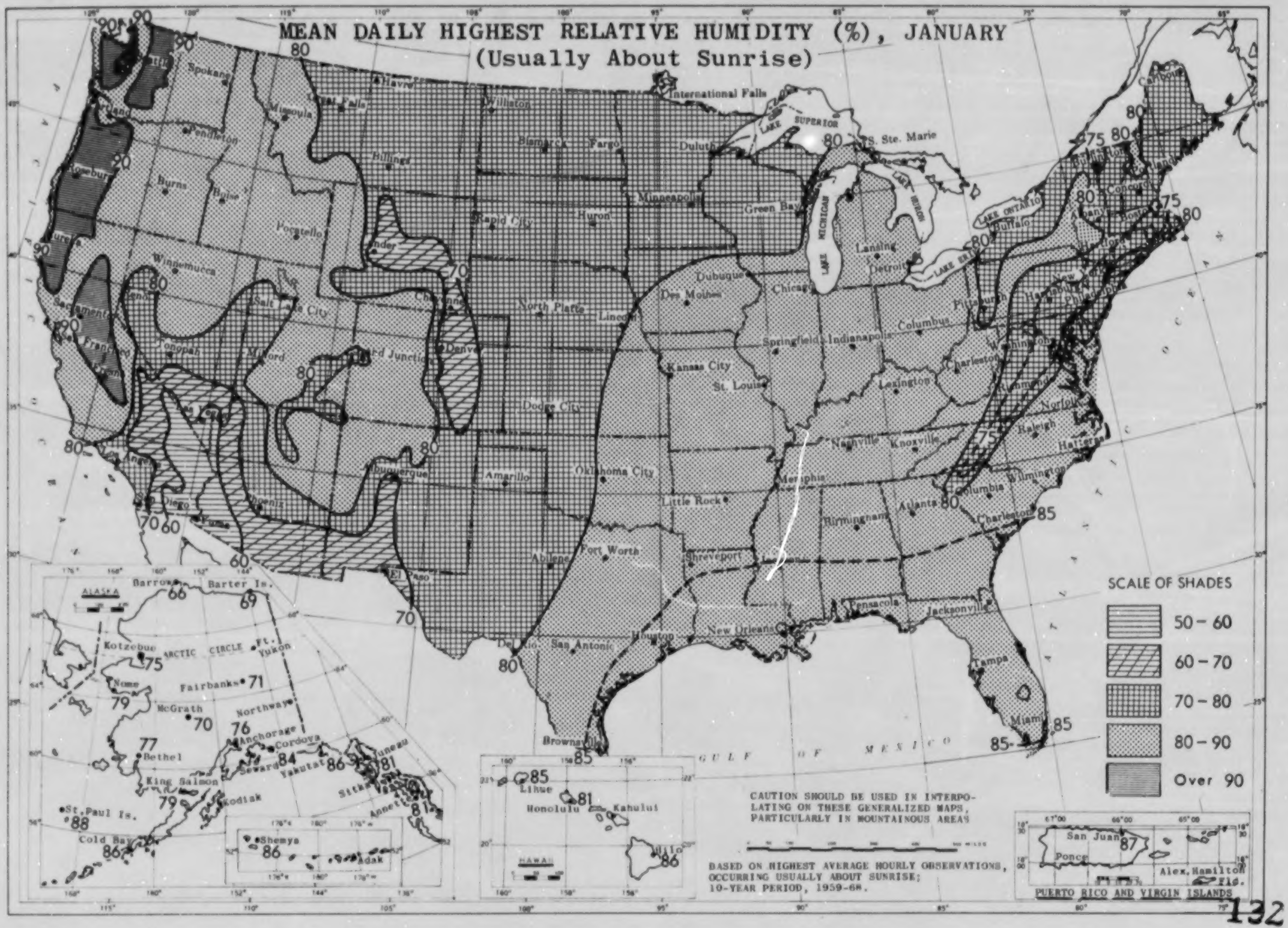
MEAN HOURLY RELATIVE HUMIDITY (%) JANUARY (Dashed Lines) AND JULY (Solid Lines)


Seattle
Spokane
Great Falls
Bismarck
International Falls
S. Ste. Marie
Burlington
Caribou
Portland
Salt Lake City
Sheridan
North Platte
Minneapolis
Chicago
Buffalo
New York
Boston
San Francisco
Denver
St. Louis
Cincinnati
Washington
Fresno
Los Angeles
Phoenix
Dodge City
Memphis
Atlanta
Charleston
El Paso
Fort Worth
Barrow
Fairbanks
New Orleans
Tampa
Miami
Nome
Anchorage
Juneau
Brownsville
Key West
San Juan
Cold Bay
ALASKA
Honolulu
PUERTO RICO AND VIRGIN ISLANDS
GULF OF MEX
A M
P M

LEGEND:
DASHED LINES JANUARY DATA
SOLID LINES JULY DATA

BASED ON HOURLY OBSERVATIONS
DURING 15-YEAR PERIOD 1954-68

Map 40

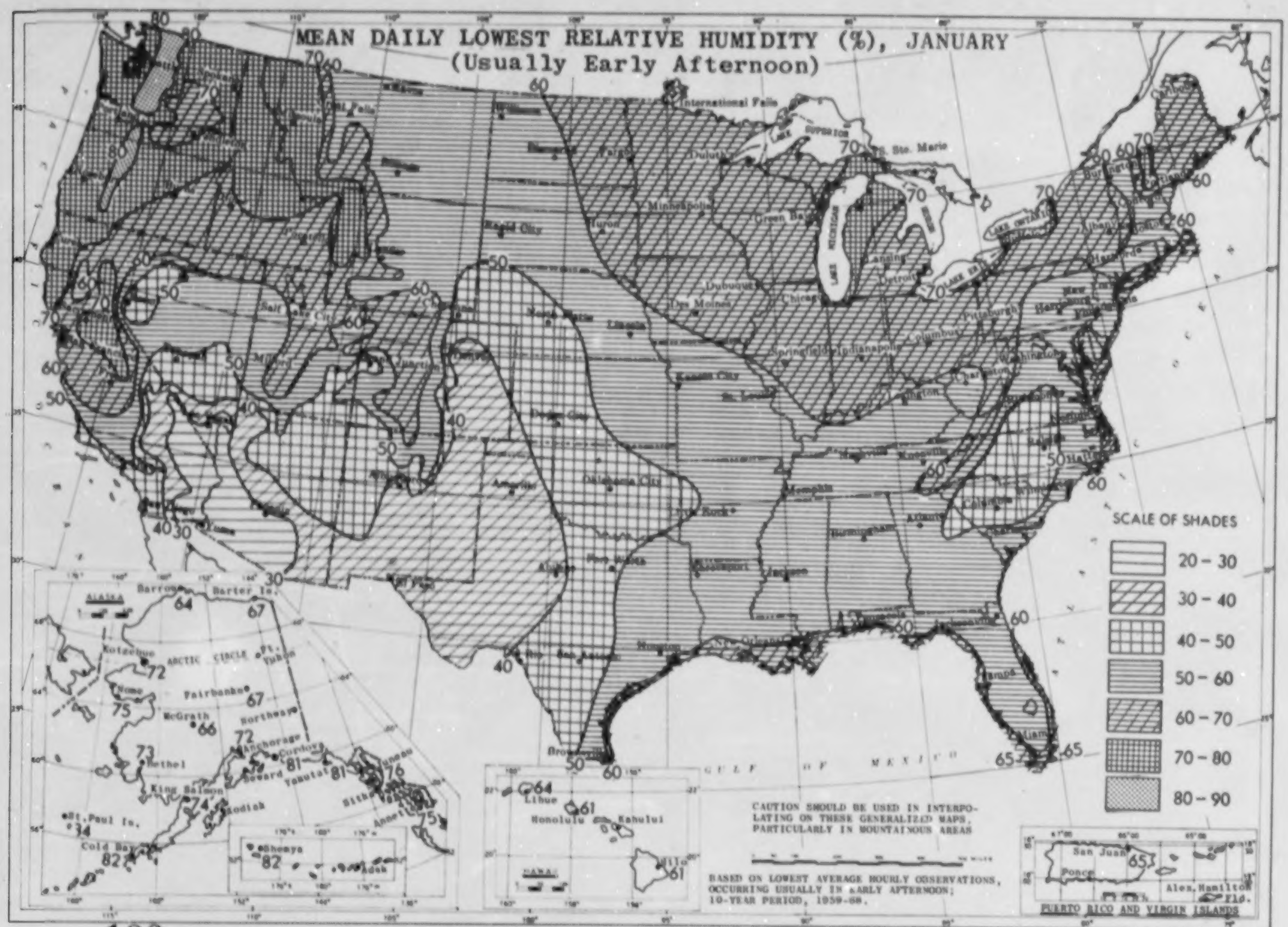


MEAN DAILY HIGHEST RELATIVE HUMIDITY (%), JANUARY
(Usually About Sunrise)

SCALE OF SHADES
50 – 60
60 – 70
70 – 80
80 – 90
Over 90
ALASKA
Barrow 66
Barter Is. 69
Kotzebue 75
ARCTIC CIRCLE
Ft. Yukon
Nome 79
Fairbanks 71
McGrath 70
Northway 76
Bethel 77
Anchorage
Cordova
Seward 84
Yakutat 86
Juneau 81
Sitka
Annette 81
King Salmon 79
Kodiak
St. Paul Is. 88
Cold Bay 86
Shemya 86
Adak
HAWAII
Lihue 85
Honolulu 81
Kahului
Hilo 86
PUERTO RICO AND VIRGIN ISLANDS
San Juan 87
Ponce
Alex. Hamilton Fld.
International Falls
LAKE SUPERIOR
S. Ste. Marie
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GULF OF MEXICO
Spokane
Portland
Pendleton
Roseburg
Eureka
Burns
Boise
Pocatello
Winnemucca
Sacramento
San Francisco
Fresno
Tonopah
Milford
Salt Lake City
Grand Junction
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
El Paso
Missoula
Havre
Great Falls
Billings
Lander
Cheyenne
Denver
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
Duluth
Minneapolis
Green Bay
Des Moines
Dubuque
Chicago
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Lansing
Detroit
Pittsburgh
Buffalo
Lexington
Charleston
Nashville
Knoxville
Memphis
Little Rock
Shreveport
New Orleans
Birmingham
Atlanta
Pensacola
Jacksonville
Tampa
Miami
Columbia
Wilmington
Charleston
Raleigh
Norfolk
Hatteras
Richmond
Washington
Philadelphia
Harrisburg
New York
Albany
Boston
Concord
Burlington
Caribou
ATLANTIC OCEAN
PACIFIC OCEAN
90
80
70
60
75
85

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS

BASED ON HIGHEST AVERAGE HOURLY OBSERVATIONS, OCCURRING USUALLY ABOUT SUNRISE; 10-YEAR PERIOD, 1959-68.



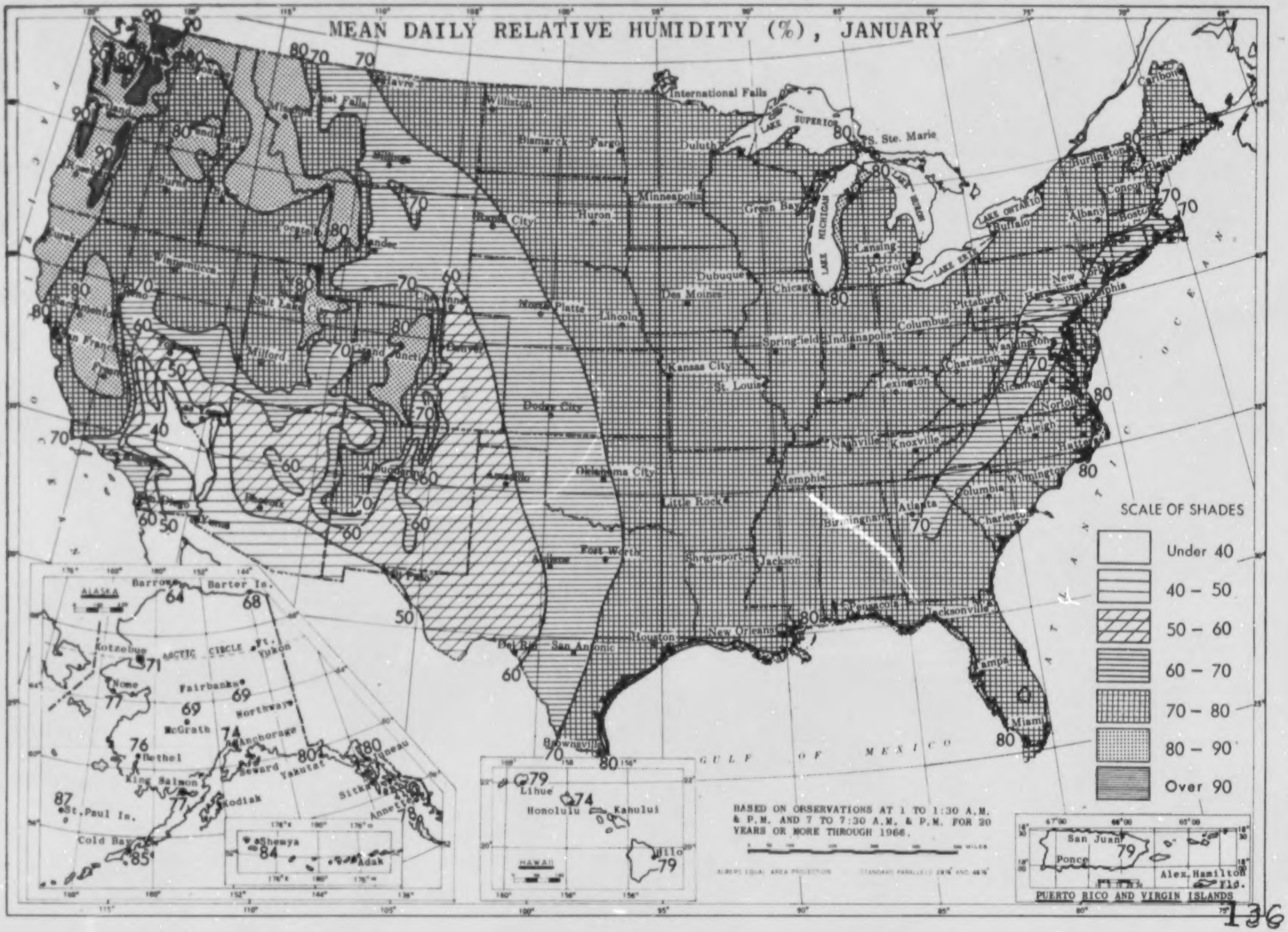
MEAN DAILY LOWEST RELATIVE HUMIDITY (%), JANUARY
(Usually Early Afternoon)

SCALE OF SHADES
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
International Falls
Sault Ste. Marie
Duluth
Fargo
Minneapolis
Green Bay
Huron
Rapid City
Dubuque
Des Moines
Chicago
Lansing
Detroit
North Platte
Lincoln
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
New York
Philadelphia
Washington
Albany
Burlington
Caribou
Salt Lake City
Dodge City
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Birmingham
Atlanta
Jackson
Shreveport
Abilene
Fort Worth
San Antonio
Houston
New Orleans
Brownsville
Tampa
Miami
Key West
Raleigh
Charleston
Columbia
Norfolk
GULF OF MEXICO
ALASKA
Barrow 64
Barter Is. 67
Kotzebue 72
ARCTIC CIRCLE
Ft. Yukon
Nome 75
Fairbanks 67
McGrath 66
Northway
Anchorage 72
Bethel 73
Cordova 81
Seward
Yakutat 81
Juneau 76
Sitka
Annette 75
King Salmon
Kodiak 74
St. Paul Is. 84
Cold Bay 82
Shemya 82
Adak
HAWAII
Lihue 64
Honolulu 61
Kahului
Hilo 61
San Juan 65
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS

BASED ON LOWEST AVERAGE HOURLY OBSERVATIONS, OCCURRING USUALLY IN EARLY AFTERNOON; 10-YEAR PERIOD, 1959-68.

Map 42



MEAN DAILY RELATIVE HUMIDITY (%), JANUARY

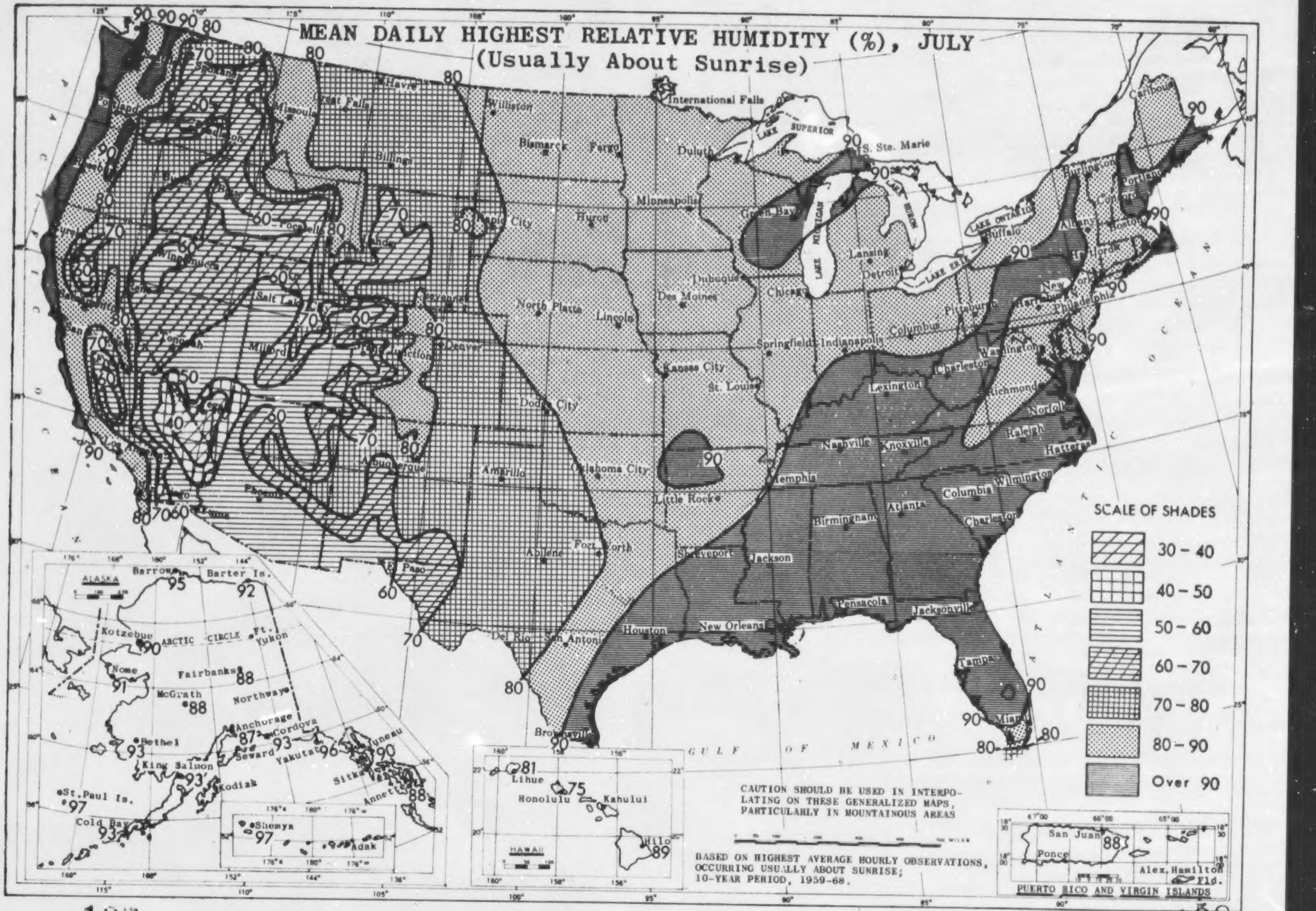
SCALE OF SHADES

□	Under 40
▤	40 – 50
▨	50 – 60
▤	60 – 70
▦	70 – 80
▒	80 – 90
■	Over 90

BASED ON OBSERVATIONS AT 1 TO 1:30 A.M. & P.M. AND 7 TO 7:30 A.M. & P.M. FOR 20 YEARS OR MORE THROUGH 1966.

90
80
70
60
50
40
International Falls
LAKE SUPERIOR
S. Ste. Marie
Williston
Havre
Great Falls
Bismarck
Fargo
Duluth
Minneapolis
Green Bay
Huron
Rapid City
Lander
Winnemucca
Salt Lake City
Eureka
Sacramento
San Francisco
Fresno
Milford
Grand Junction
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
LAKE MICHIGAN
LAKE HURON
Lansing
Detroit
LAKE ERIE
LAKE ONTARIO
Buffalo
Burlington
Caribou
Portland
Concord
Albany
Boston
New York
Harrisburg
Philadelphia
Pittsburgh
Columbus
Indianapolis
Springfield
Denver
Kansas City
St. Louis
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Dodge City
Albuquerque
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Wilmington
Columbia
Atlanta
Birmingham
Charleston
Phoenix
Yuma
San Diego
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALASKA
Barrow
64
Barter Is.
68
Kotzebue
ARCTIC CIRCLE
Ft. Yukon
71
Nome
77
Fairbanks
69
McGrath
69
Northway
Bethel
76
Anchorage
74
King Salmon
77
Seward
Yakutat
80
Juneau
80
Sitka
Annette
Kodiak
St. Paul Is.
87
Cold Bay
85
Shemya
84
Adak
HAWAII
Lihue
79
Honolulu
74
Kahului
Hilo
79
San Juan
79
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES

Map 43



MEAN DAILY HIGHEST RELATIVE HUMIDITY (%), JULY
(Usually About Sunrise)

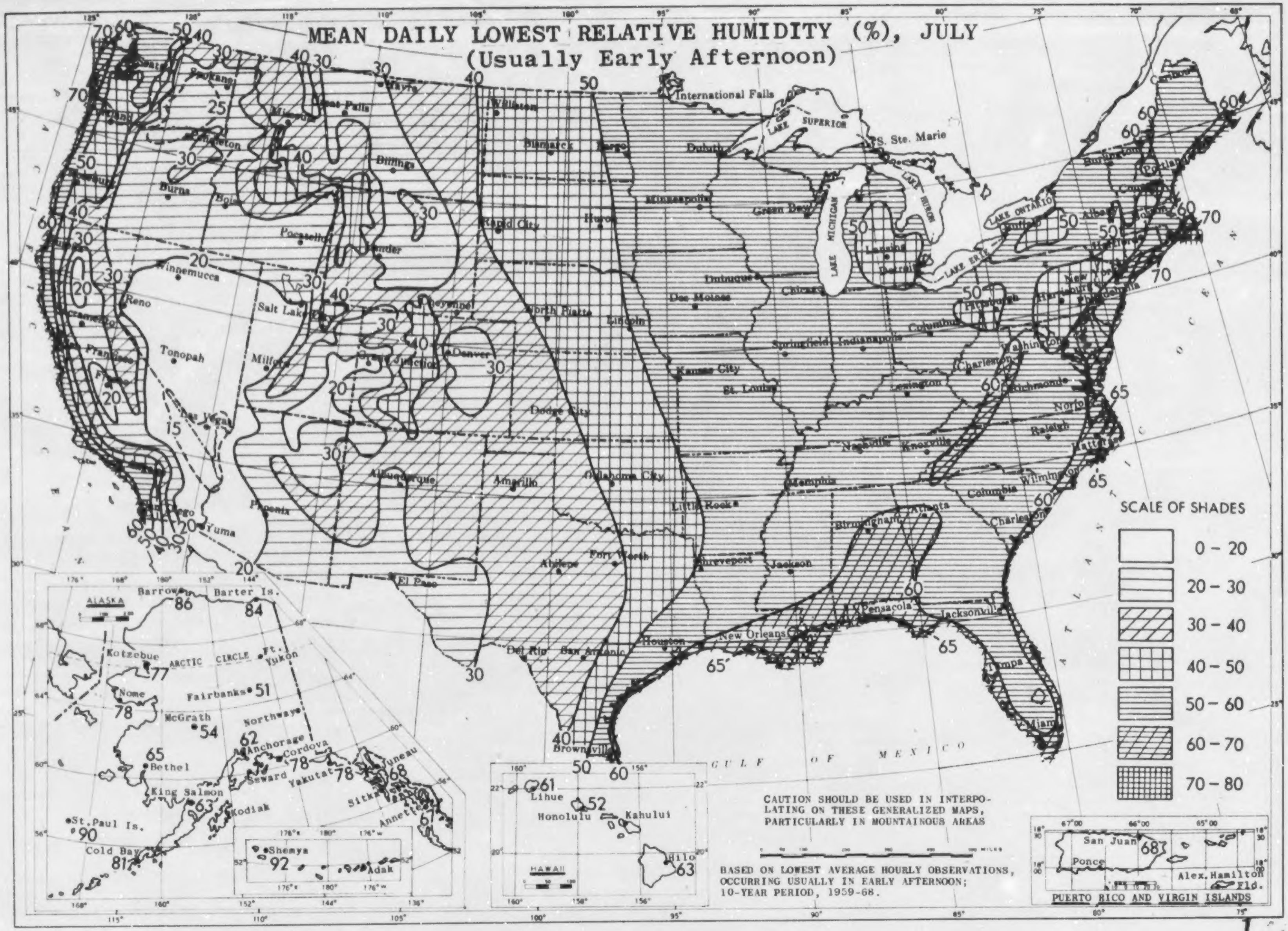
SCALE OF SHADES
▨ 30 - 40
▦ 40 - 50
▤ 50 - 60
▨ 60 - 70
▦ 70 - 80
░ 80 - 90
▓ Over 90
P A C I F I C O C E A N
A T L A N T I C O C E A N
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Portland
Spokane
Missoula
Great Falls
Havre
Billings
Pocatello
Winnemucca
Salt Lake City
Reno
Tonopah
Milford
Grand Junction
Cheyenne
Denver
Rapid City
Williston
Bismarck
Fargo
Huron
International Falls
Duluth
Minneapolis
Green Bay
S. Ste. Marie
Lansing
Detroit
Buffalo
Burlington
Caribou
Portland
Concord
Boston
Albany
Hartford
New York
Philadelphia
Pittsburgh
Columbus
Indianapolis
Springfield
Chicago
Dubuque
Des Moines
North Platte
Lincoln
Kansas City
St. Louis
Dodge City
Amarillo
Oklahoma City
Little Rock
Albuquerque
Phoenix
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Memphis
Nashville
Knoxville
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Pensacola
Jacksonville
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Tampa
Miami
90
80
70
60
50
40
ALASKA
Barrow 95
Barter Is. 92
Kotzebue 90
ARCTIC CIRCLE
Ft. Yukon
Nome 91
Fairbanks 88
McGrath 88
Northway
Anchorage 87
Cordova 93
Seward
Yakutat 96
Juneau 90
Bethel 93
King Salmon 93
Kodiak
Sitka
Annette 88
St. Paul Is. 97
Cold Bay 93
Shemya 97
Adak
HAWAII
Lihue 81
Honolulu 75
Kahului
Hilo 89
San Juan 88
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS

BASED ON HIGHEST AVERAGE HOURLY OBSERVATIONS, OCCURRING USUALLY ABOUT SUNRISE; 10-YEAR PERIOD, 1959-68.

Map 44

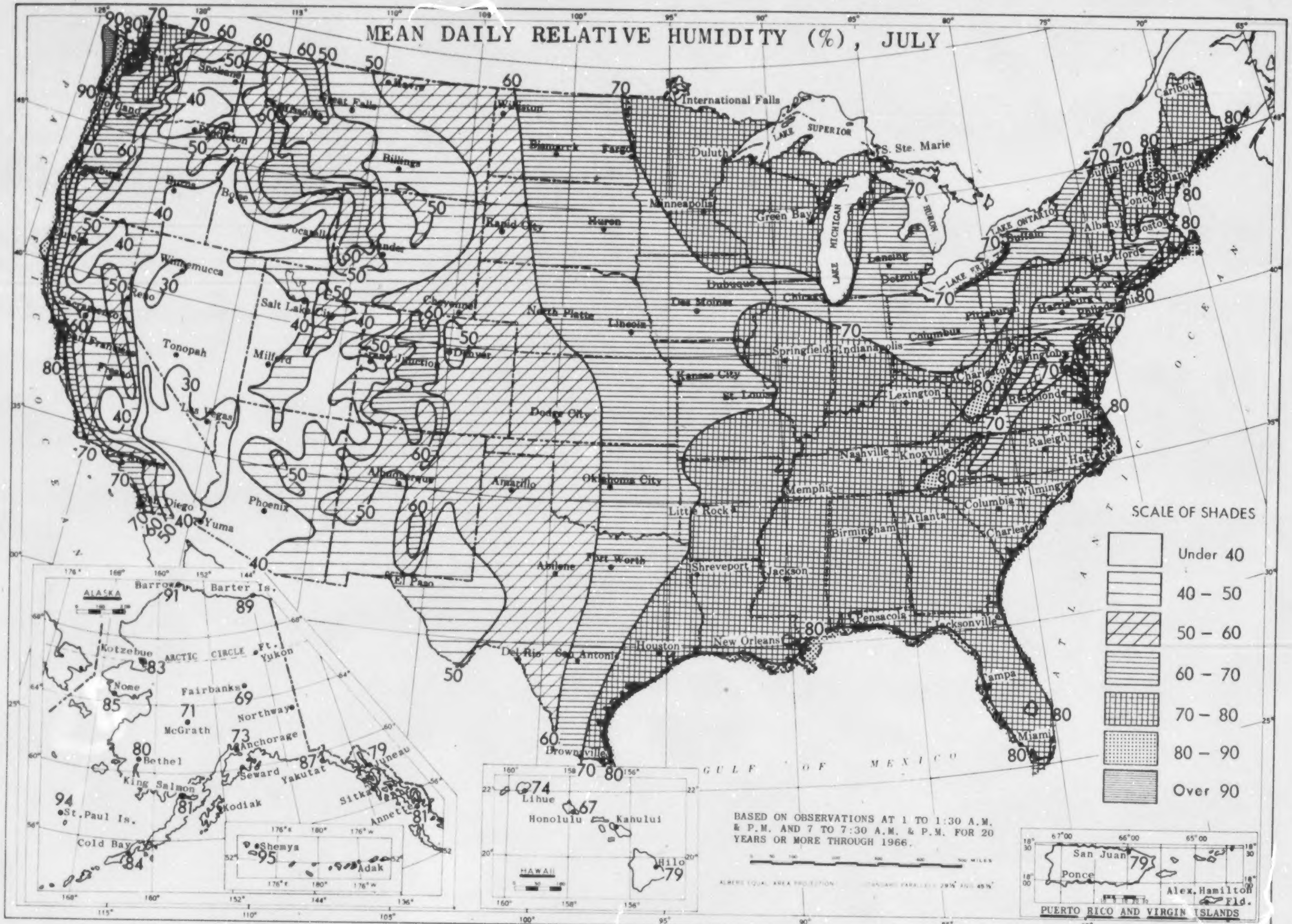
MEAN DAILY LOWEST RELATIVE HUMIDITY (%), JULY
(Usually Early Afternoon)


SCALE OF SHADES
0 – 20
20 – 30
30 – 40
40 – 50
50 – 60
60 – 70
70 – 80
ALASKA
Barrow 86
Barter Is. 84
Kotzebue 77
ARCTIC CIRCLE
Ft. Yukon
Fairbanks 51
Nome 78
McGrath 54
Northway
Anchorage 62
Cordova 78
Yakutat 78
Juneau 68
Bethel 65
Seward
King Salmon 63
Kodiak
Sitka
Annette 67
St. Paul Is. 90
Cold Bay 81
Shemya 92
Adak
HAWAII
Lihue 61
Honolulu 52
Kahului
Hilo 63
PUERTO RICO AND VIRGIN ISLANDS
San Juan 68
Ponce
Alex. Hamilton Fld.
GULF OF MEXICO
International Falls
LAKE SUPERIOR
S. Ste. Marie
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Seattle
Spokane
Great Falls
Havre
Williston
Bismarck
Fargo
Duluth
Portland
Pendleton
Missoula
Billings
Burns
Boise
Pocatello
Lander
Rapid City
Huron
Minneapolis
Green Bay
Winnemucca
Reno
Salt Lake City
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
Buffalo
Albany
Burlington
Portland
Concord
Boston
Hartford
New York
Harrisburg
Philadelphia
Pittsburgh
Columbus
Indianapolis
Springfield
Kansas City
St. Louis
Denver
Grand Junction
Milford
Tonopah
San Francisco
Fresno
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
Amarillo
Dodge City
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Jackson
Shreveport
Fort Worth
Abilene
El Paso
Del Rio
San Antonio
Houston
Brownsville
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Caribou
ATLANTIC OCEAN
PACIFIC OCEAN
15
20
25
30
40
50
60
65
70

CAUTION SHOULD BE USED IN INTERPOLATING ON THESE GENERALIZED MAPS, PARTICULARLY IN MOUNTAINOUS AREAS

BASED ON LOWEST AVERAGE HOURLY OBSERVATIONS, OCCURRING USUALLY IN EARLY AFTERNOON; 10-YEAR PERIOD, 1959-68.

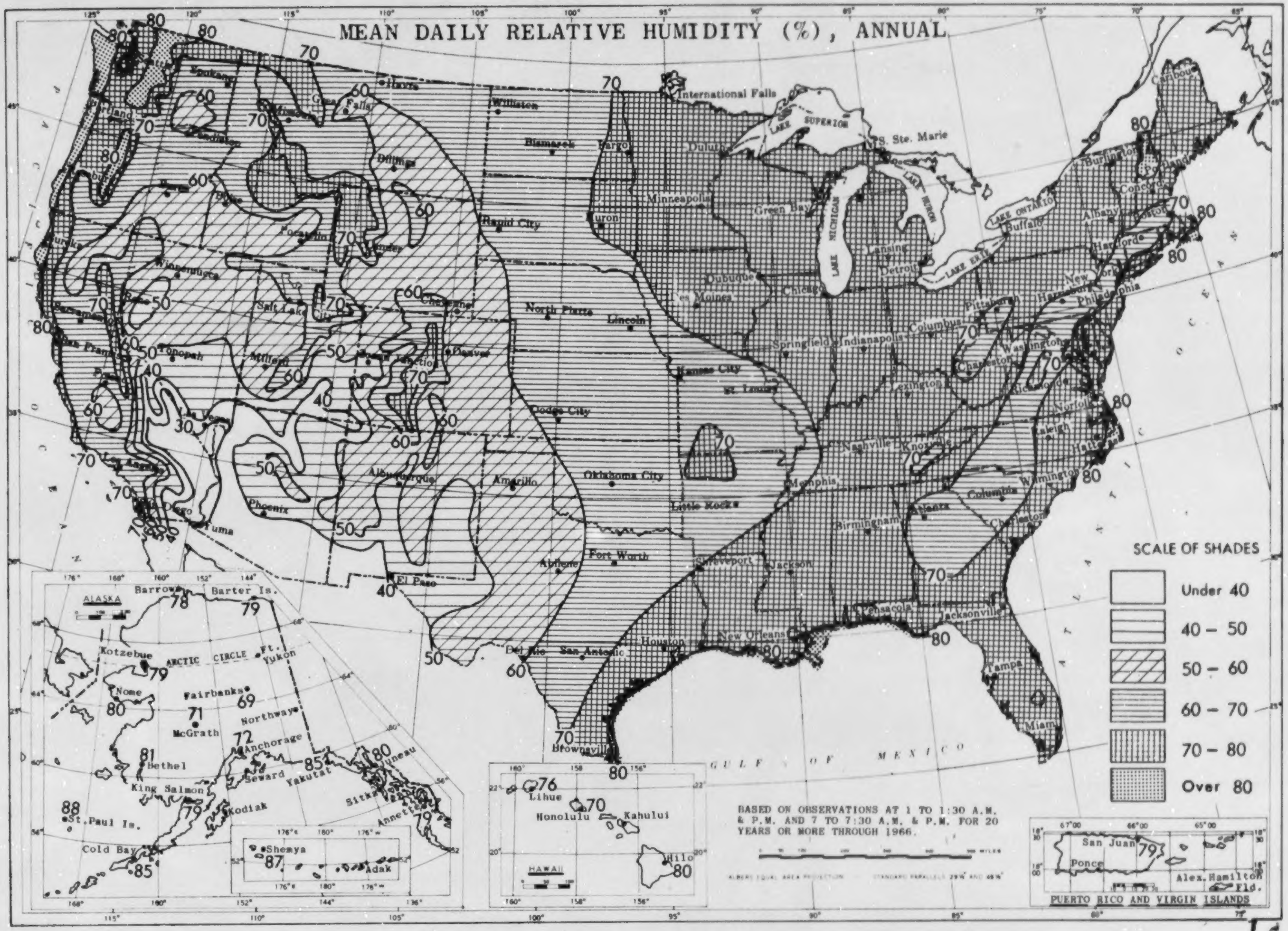
MEAN DAILY RELATIVE HUMIDITY (%), JULY


SCALE OF SHADES
Under 40
40 – 50
50 – 60
60 – 70
70 – 80
80 – 90
Over 90
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
HURON
LAKE ONTARIO
LAKE ERIE
International Falls
Duluth
S. Ste. Marie
Caribou
Burlington
Concord
Portland
Boston
Albany
Hartford
New York
Buffalo
Detroit
Lansing
Green Bay
Minneapolis
Fargo
Bismarck
Williston
Great Falls
Spokane
Seattle
Portland
Pendleton
Billings
Boise
Pocatello
Lander
Rapid City
Huron
Dubuque
Des Moines
Chicago
Salt Lake City
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Milford
Grand Junction
Cheyenne
Denver
North Platte
Lincoln
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
Philadelphia
Washington
Charleston
Lexington
Richmond
Norfolk
Raleigh
Hatteras
Nashville
Knoxville
Memphis
Little Rock
Oklahoma City
Dodge City
Amarillo
Albuquerque
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Birmingham
Atlanta
Columbia
Wilmington
Charleston
Pensacola
Jacksonville
Tampa
Miami
New Orleans
Houston
San Antonio
Del Rio
Brownsville
ALASKA
Barrow 91
Barter Is. 89
ARCTIC CIRCLE
Kotzebue 83
Ft. Yukon
Nome 85
Fairbanks 69
McGrath 71
Northway
Anchorage 73
Bethel 80
Seward
Yakutat 87
Juneau 79
Sitka
Annette 81
King Salmon 81
Kodiak
St. Paul Is. 94
Cold Bay 84
Shemya 95
Adak
HAWAII
Lihue 74
Honolulu 67
Kahului
Hilo 79
San Juan 79
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION STANDARD PARALLELS 29½° AND 45½°

BASED ON OBSERVATIONS AT 1 TO 1:30 A.M. & P.M. AND 7 TO 7:30 A.M. & P.M. FOR 20 YEARS OR MORE THROUGH 1966.

Map 46

MEAN DAILY RELATIVE HUMIDITY (%), ANNUAL


International Falls
Duluth
Minneapolis
Green Bay
Sault Ste. Marie
Lansing
Detroit
Chicago
Dubuque
Des Moines
Springfield
Indianapolis
Columbus
Pittsburgh
Buffalo
Albany
Burlington
Portland
Concord
Boston
Hartford
New York
Philadelphia
Harrisburg
Washington
Charleston
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Jacksonville
Tampa
Miami
Pensacola
New Orleans
Jackson
Birmingham
Nashville
Knoxville
Lexington
Memphis
Little Rock
St. Louis
Kansas City
Shreveport
Houston
San Antonio
Del Rio
Brownsville
Fort Worth
Abilene
Oklahoma City
Amarillo
Dodge City
Lincoln
North Platte
Huron
Rapid City
Bismarck
Fargo
Williston
Havre
Great Falls
Billings
Missoula
Spokane
Seattle
Portland
Boise
Pocatello
Lander
Cheyenne
Denver
Grand Junction
Salt Lake City
Milford
Winnemucca
Tonopah
Sacramento
San Francisco
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
El Paso
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
30
40
50
60
70
80
ALASKA
Barrow 78
Barter Is. 79
Kotzebue 79
ARCTIC CIRCLE
Ft. Yukon
Nome 80
Fairbanks 69
McGrath 71
Northway
Anchorage 72
Bethel 81
King Salmon 79
Seward
Yakutat 85
Juneau 80
Sitka
Annette 79
Kodiak
St. Paul Is. 88
Cold Bay 85
Shemya 87
Adak
HAWAII
Lihue 76
Honolulu 70
Kahului
Hilo 80
San Juan 79
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

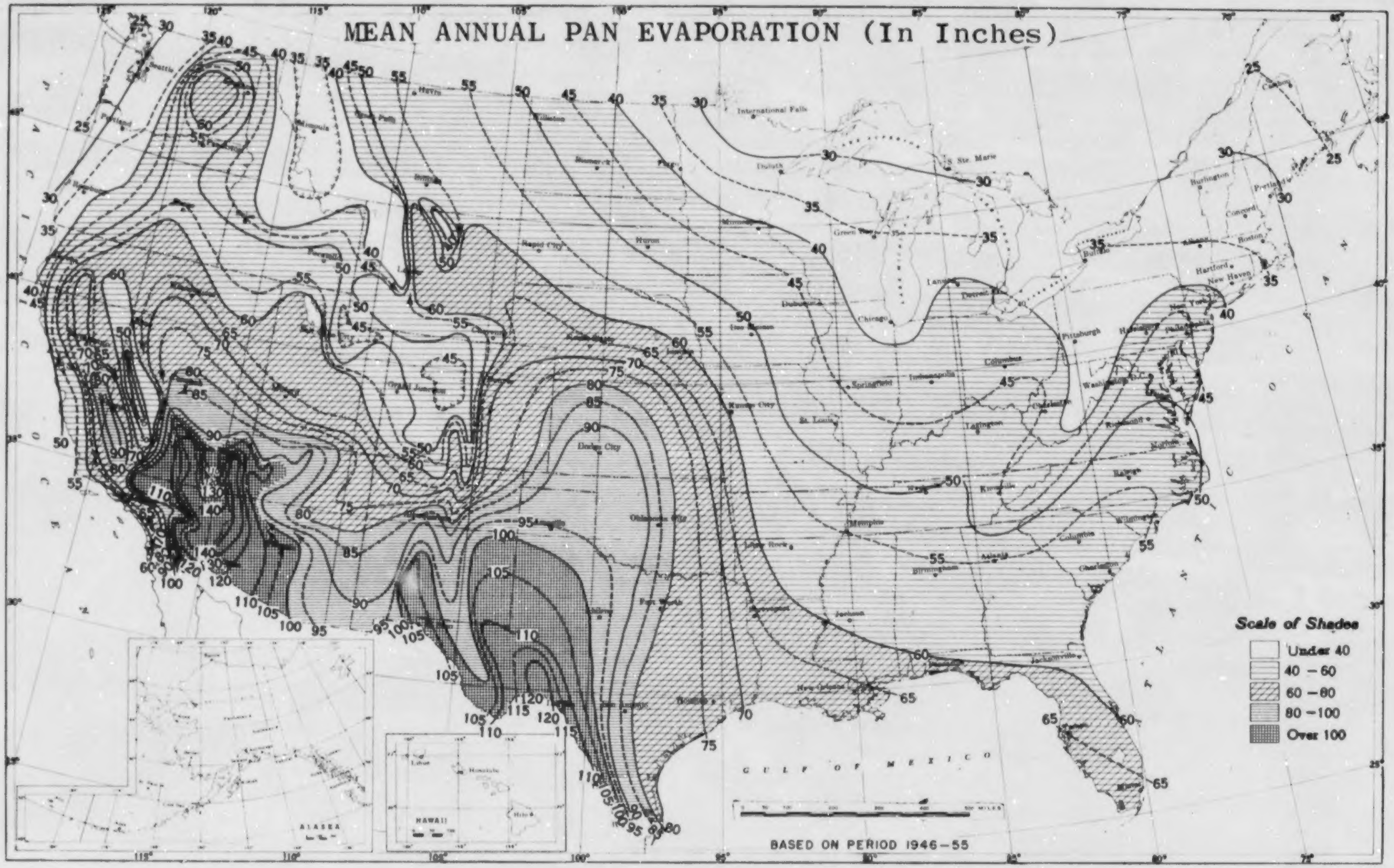
SCALE OF SHADES

□ Under 40
▤ 40 – 50
▨ 50 – 60
▤ 60 – 70
▦ 70 – 80
▩ Over 80

BASED ON OBSERVATIONS AT 1 TO 1:30 A.M. & P.M. AND 7 TO 7:30 A.M. & P.M. FOR 20 YEARS OR MORE THROUGH 1966.

143

Map 47

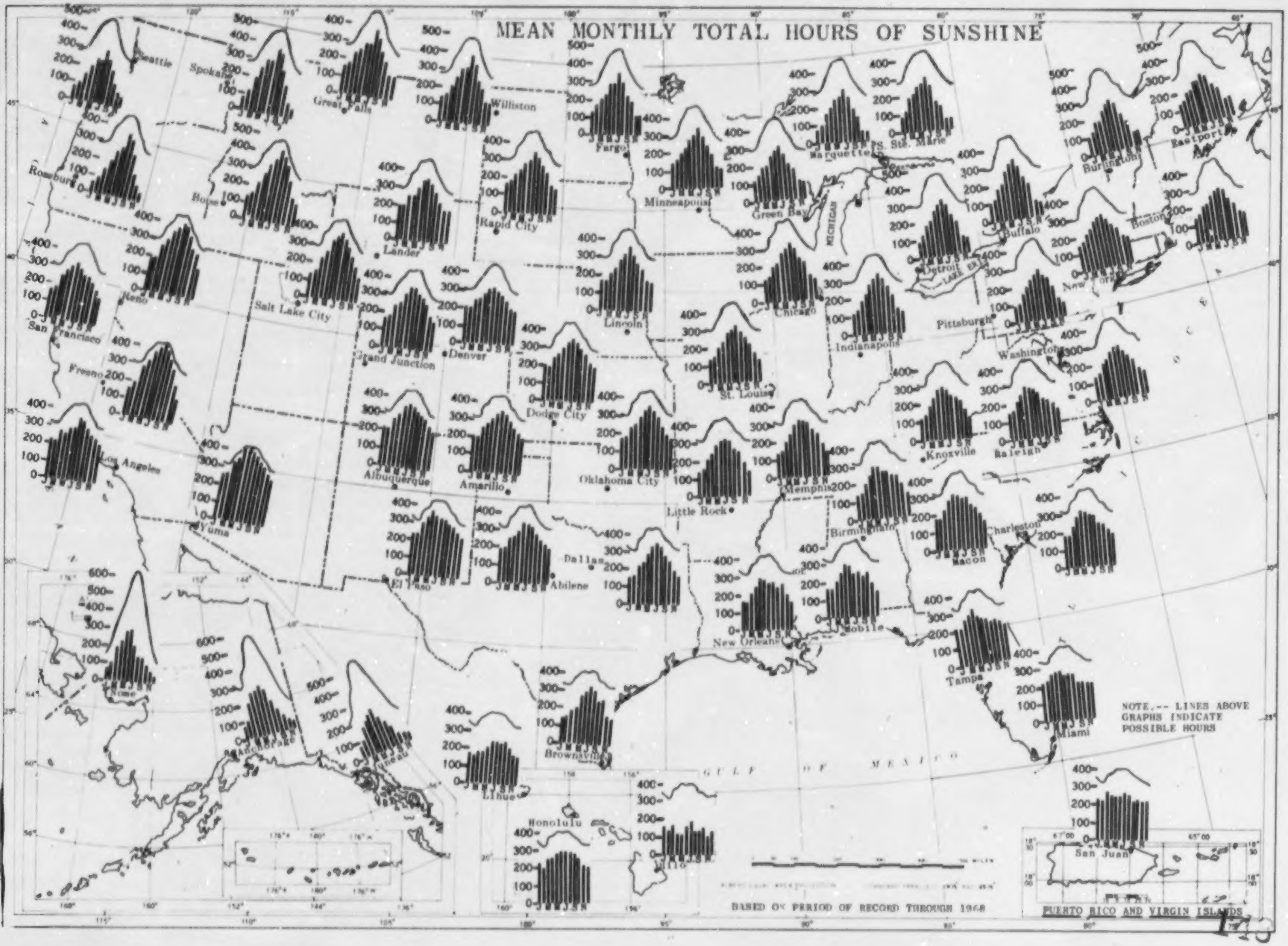


MEAN ANNUAL PAN EVAPORATION (In Inches)

BASED ON PERIOD 1946–55

Scale of Shades
Under 40
40 – 60
60 – 80
80 – 100
Over 100
GULF OF MEXICO
ALASKA
HAWAII
International Falls
Duluth
Chicago
Pittsburgh
Memphis
Dodge City
Oklahoma City
Kansas City
St. Louis
Birmingham
Jacksonville
New Orleans
Atlanta
Boston
New York
Hartford
New Haven
Concord
Portland
Burlington
Buffalo
Seattle
Portland
Rapid City
Huron
Green Bay
Grand Junction
Little Rock
Charleston
Columbia
Savannah
Jackson
Lansing
Detroit
Columbus
Knoxville
Nashville
Chattanooga
Indianapolis
Springfield
Washington
Richmond
Raleigh
Wilmington
Amarillo
Fort Worth
Shreveport
Honolulu
Hilo
Lihue

Map 48



MEAN MONTHLY TOTAL HOURS OF SUNSHINE

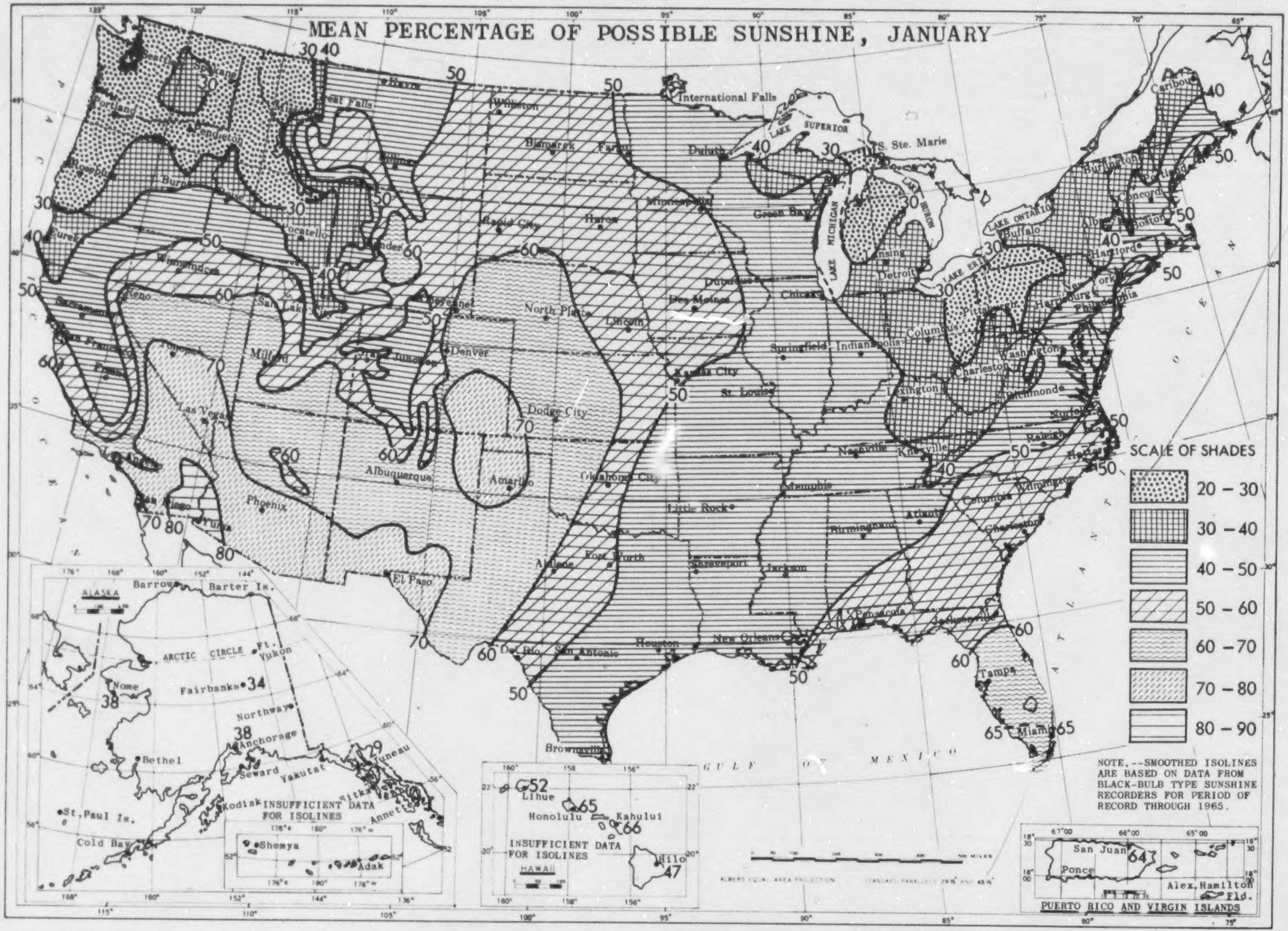
Seattle
Spokane
Great Falls
Williston
Fargo
Marquette
S. Ste. Marie
Burlington
Eastport
Roseburg
Boise
Rapid City
Minneapolis
Green Bay
Buffalo
Boston
Lander
Detroit
Reno
San Francisco
Salt Lake City
Lincoln
Chicago
New York
Fresno
Grand Junction
Denver
Dodge City
St. Louis
Indianapolis
Pittsburgh
Washington
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Knoxville
Raleigh
Yuma
Little Rock
Birmingham
Charleston
Macon
El Paso
Abilene
Dallas
New Orleans
Mobile
Tampa
Miami
Nome
Anchorage
Juneau
Brownsville
Lihue
Honolulu
Hilo
San Juan
MICHIGAN
LAKE ERIE
GULF OF MEXICO
PUERTO RICO AND VIRGIN ISLANDS
0
100
200
300
400
500
600
J M M J S N

NOTE.-- LINES ABOVE GRAPHS INDICATE POSSIBLE HOURS

BASED ON PERIOD OF RECORD THROUGH 1968

147

Map 49



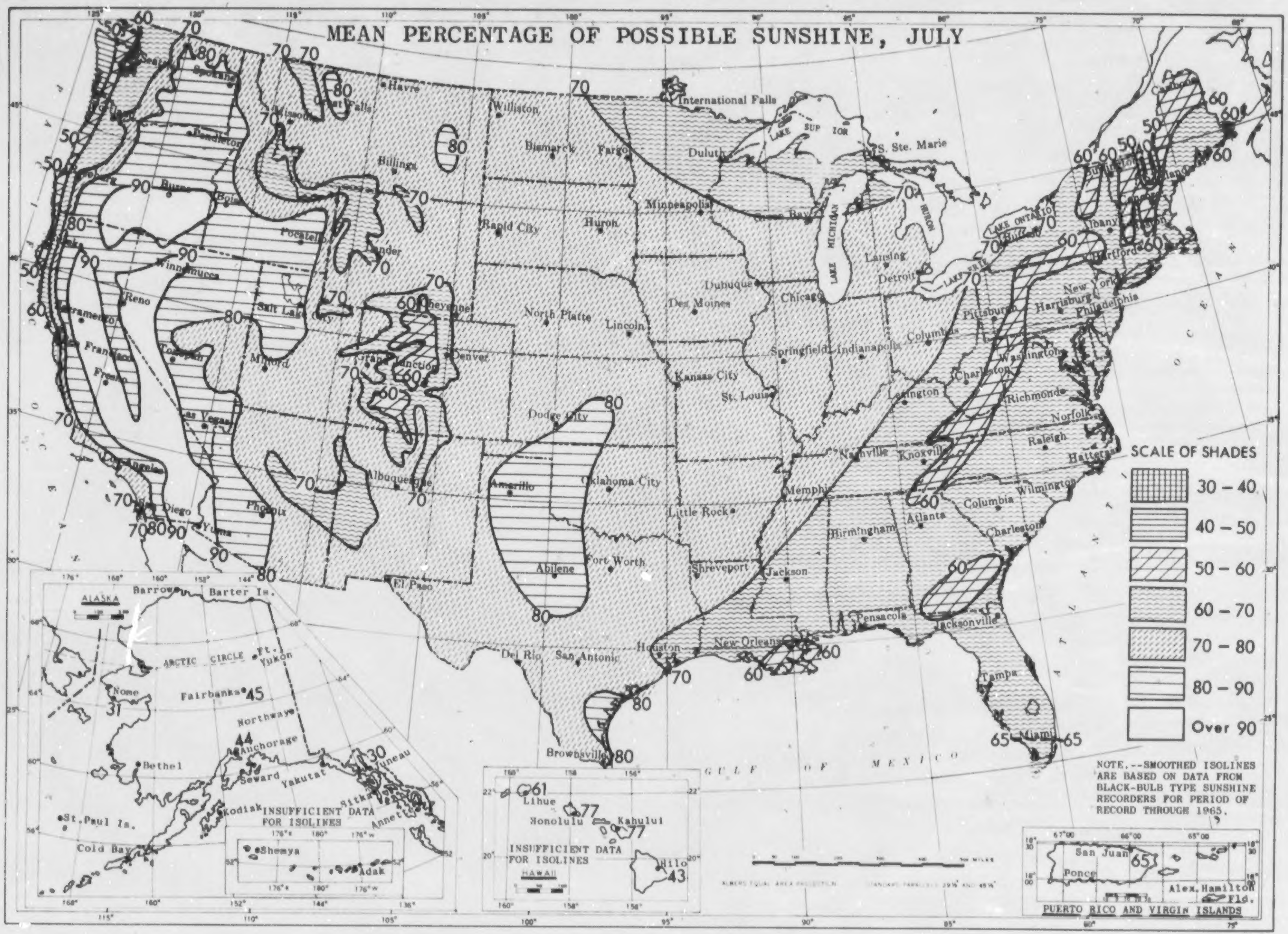
MEAN PERCENTAGE OF POSSIBLE SUNSHINE, JANUARY

SCALE OF SHADES
20 – 30
30 – 40
40 – 50
50 – 60
60 – 70
70 – 80
80 – 90
ALASKA
ARCTIC CIRCLE
Barrow
Barter Is.
Ft. Yukon
Nome 38
Fairbanks 34
Northway
Anchorage 38
Bethel
Seward
Yakutat
Juneau 29
Kodiak
Sitka
Annette
St. Paul Is.
Cold Bay
Shemya
Adak
INSUFFICIENT DATA FOR ISOLINES
HAWAII
Lihue 52
Honolulu 65
Kahului 66
Hilo 47
INSUFFICIENT DATA FOR ISOLINES
PUERTO RICO AND VIRGIN ISLANDS
San Juan 64
Ponce
Alex. Hamilton Fld.
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
International Falls
S. Ste. Marie
Caribou
Great Falls
Williston
Bismarck
Fargo
Duluth
Minneapolis
Green Bay
Huron
Rapid City
Pocatello
Lander
Winnemucca
Reno
Salt Lake City
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Detroit
Lansing
Buffalo
Burlington
Concord
Portland
Albany
Boston
Hartford
New York
Philadelphia
Harrisburg
Pittsburgh
Columbus
Indianapolis
Springfield
Kansas City
St. Louis
Denver
Grand Junction
Milford
Tonopah
Fresno
San Francisco
Sacramento
Eureka
Roseburg
Burns
Pendleton
Spokane
Seattle
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
El Paso
Amarillo
Dodge City
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Jackson
Shreveport
Fort Worth
Abilene
Del Rio
San Antonio
Houston
Brownsville
New Orleans
Pensacola
Jacksonville
Tampa
Miami
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES

NOTE.--SMOOTHED ISOLINES ARE BASED ON DATA FROM BLACK-BULB TYPE SUNSHINE RECORDERS FOR PERIOD OF RECORD THROUGH 1965.

Map 50

100



MEAN PERCENTAGE OF POSSIBLE SUNSHINE, JULY

SCALE OF SHADES

▦	30 – 40
▤	40 – 50
▨	50 – 60
▒	60 – 70
▨	70 – 80
▤	80 – 90
☐	Over 90

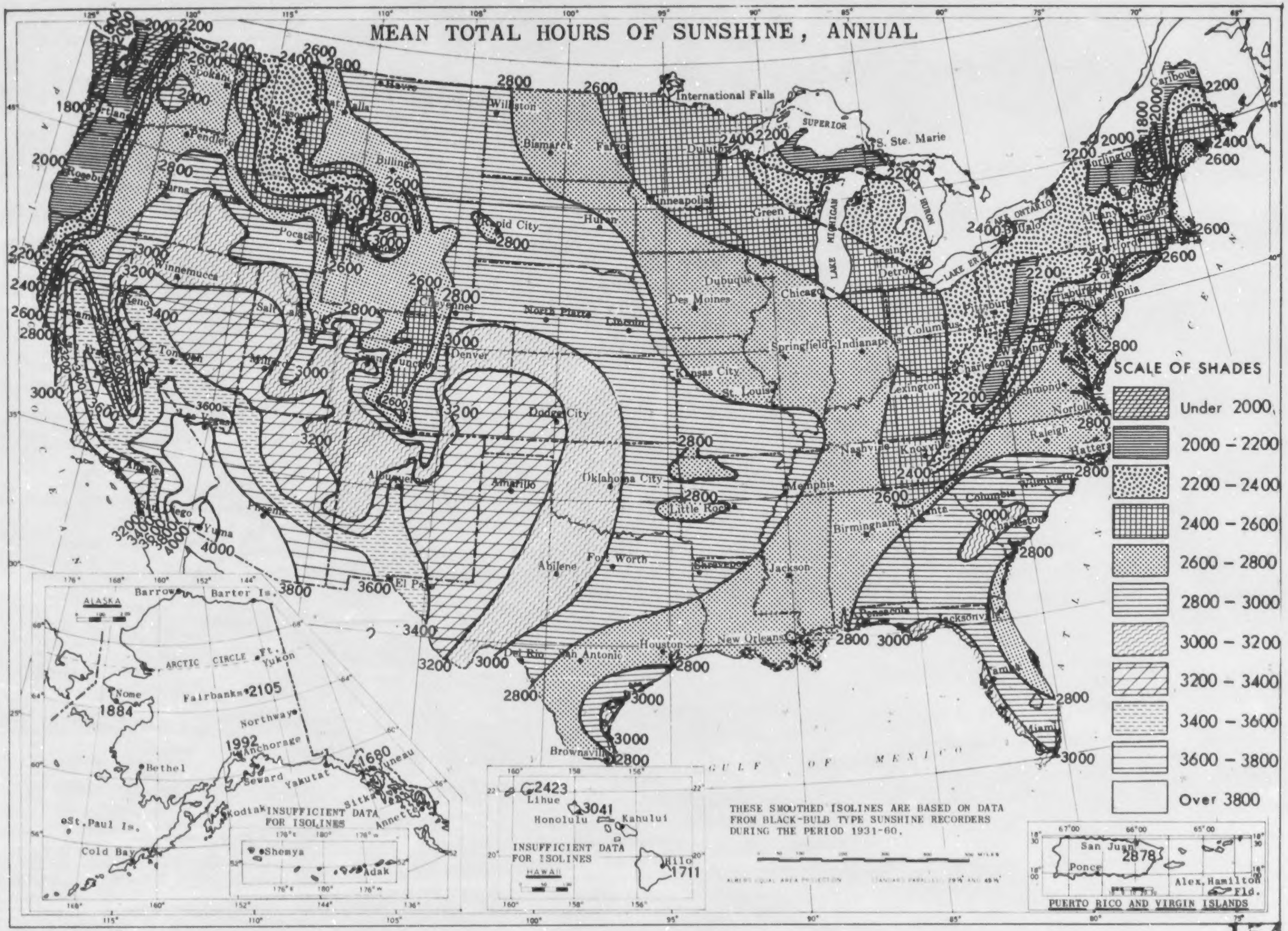
NOTE.--SMOOTHED ISOLINES ARE BASED ON DATA FROM BLACK-BULB TYPE SUNSHINE RECORDERS FOR PERIOD OF RECORD THROUGH 1965.

INSUFFICIENT DATA FOR ISOLINES

INSUFFICIENT DATA FOR ISOLINES

PUERTO RICO AND VIRGIN ISLANDS

Havre
Williston
International Falls
Spokane
Great Falls
Missoula
Pendleton
Billings
Bismarck
Fargo
Duluth
LAKE SUPERIOR
S. Ste. Marie
Burns
Boise
Pocatello
Lander
Rapid City
Huron
Minneapolis
Green Bay
LAKE MICHIGAN
HURON
LAKE ONTARIO
Buffalo
Albany
Hartford
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Salt Lake City
Milford
Cheyenne
Denver
Grand Junction
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
LAKE ERIE
Pittsburgh
Harrisburg
New York
Philadelphia
Springfield
Indianapolis
Columbus
Kansas City
St. Louis
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Albuquerque
Dodge City
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Atlanta
Columbia
Wilmington
Birmingham
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALASKA
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks
Northway
Anchorage
Bethel
Seward
Yakutat
Juneau
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
Alex. Hamilton Fld.
31
45
44
30
61
77
77
43
65
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

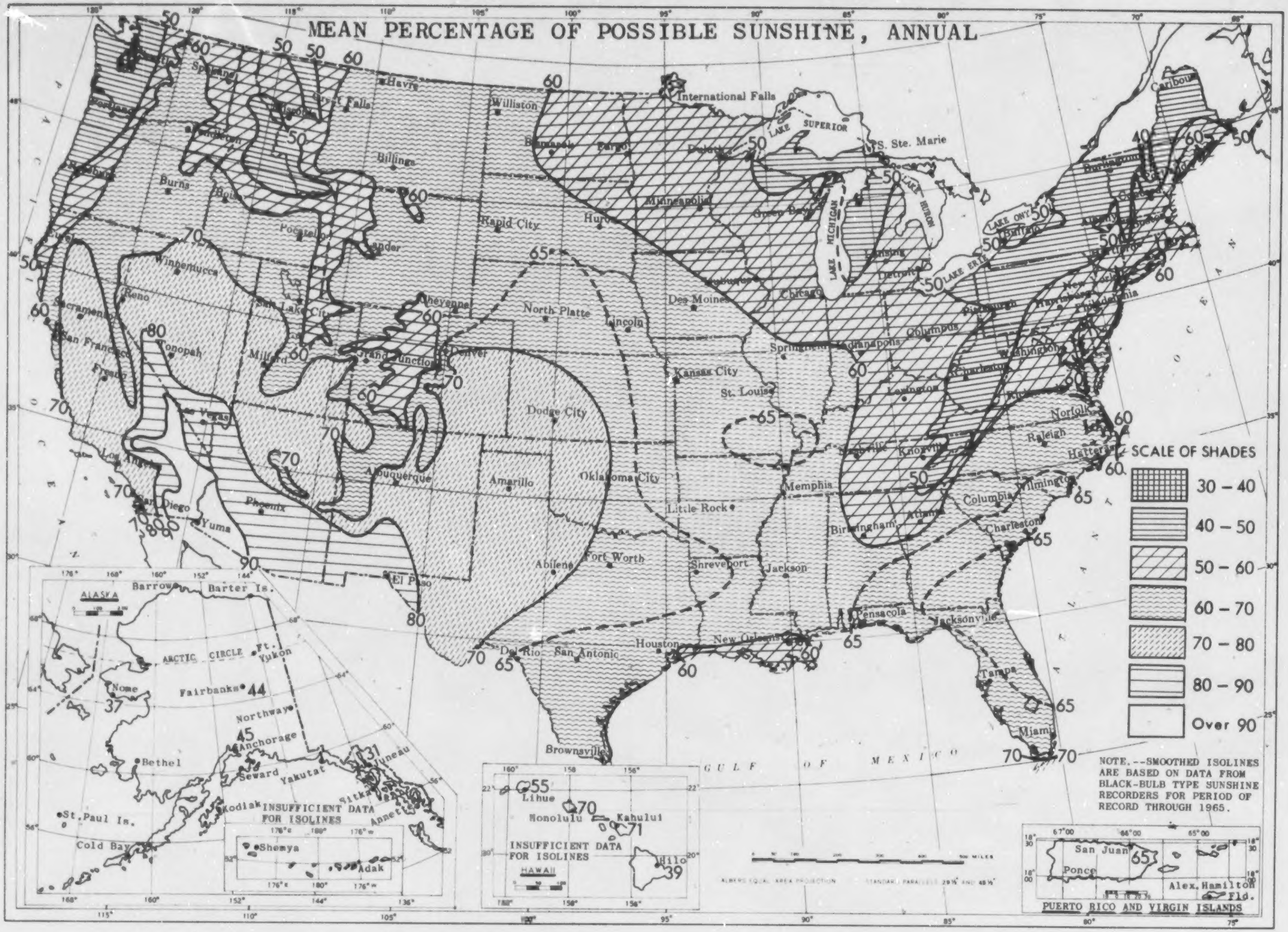


MEAN TOTAL HOURS OF SUNSHINE, ANNUAL

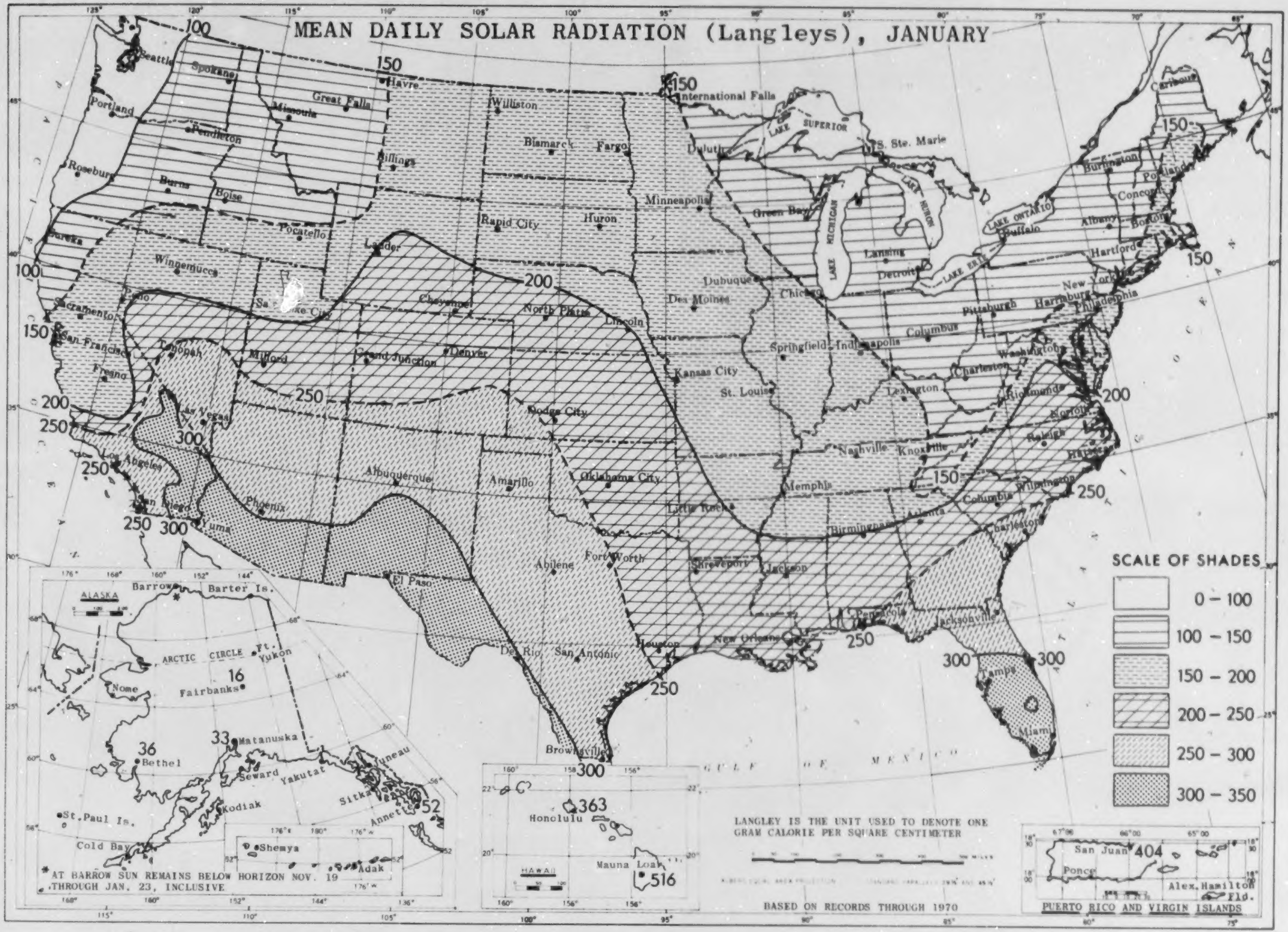
SCALE OF SHADES
Under 2000
2000 – 2200
2200 – 2400
2400 – 2600
2600 – 2800
2800 – 3000
3000 – 3200
3200 – 3400
3400 – 3600
3600 – 3800
Over 3800
International Falls
SUPERIOR
S. Ste. Marie
LAKE MICHIGAN
HURON
LAKE ONTARIO
LAKE ERIE
Williston
Bismarck
Fargo
Duluth
Minneapolis
Huron
Rapid City
Havre
Spokane
Portland
Pendleton
Roseburg
Burns
Billings
Pocatello
Winnemucca
Reno
Salt Lake
Tonopah
Milford
Cheyenne
Grand Junction
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Green Bay
Lansing
Detroit
Buffalo
Albany
Burlington
Caribou
Boston
New York
Philadelphia
Harrisburg
Pittsburgh
Columbus
Indianapolis
Springfield
St. Louis
Kansas City
Dodge City
Amarillo
Oklahoma City
Little Rock
Memphis
Nashville
Knoxville
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Birmingham
Jackson
Shreveport
Fort Worth
Abilene
El Paso
Albuquerque
Phoenix
Yuma
San Diego
Los Angeles
Las Vegas
Sacramento
San Francisco
Del Rio
San Antonio
Houston
Brownsville
New Orleans
Pensacola
Jacksonville
Tampa
Miami
GULF OF MEXICO
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
ALASKA
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome
1884
Fairbanks
2105
Northway
Anchorage
1992
Bethel
Seward
Yakutat
Juneau
1680
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
INSUFFICIENT DATA FOR ISOLINES
Shemya
Adak
Lihue
2423
Honolulu
3041
Kahului
Hilo
1711
INSUFFICIENT DATA FOR ISOLINES
HAWAII
San Juan
2878
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

THESE SMOOTHED ISOLINES ARE BASED ON DATA FROM BLACK-BULB TYPE SUNSHINE RECORDERS DURING THE PERIOD 1931-60.

MEAN PERCENTAGE OF POSSIBLE SUNSHINE, ANNUAL


SCALE OF SHADES
▦ 30 – 40
▤ 40 – 50
▨ 50 – 60
▒ 60 – 70
▧ 70 – 80
☰ 80 – 90
☐ Over 90
NOTE.--SMOOTHED ISOLINES ARE BASED ON DATA FROM BLACK-BULB TYPE SUNSHINE RECORDERS FOR PERIOD OF RECORD THROUGH 1965.
ALASKA
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome 37
Fairbanks 44
Northway
Anchorage 45
Bethel
Seward
Yakutat
Juneau 31
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
INSUFFICIENT DATA FOR ISOLINES
Shemya
Adak
HAWAII
Lihue 55
Honolulu 70
Kahului 71
Hilo 39
INSUFFICIENT DATA FOR ISOLINES
PUERTO RICO AND VIRGIN ISLANDS
San Juan 65
Ponce
Alex. Hamilton Fld.
GULF OF MEXICO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°
MILES
International Falls
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONT.
LAKE ERIE
PACIFIC OCEAN
ATLANTIC OCEAN

Map 53



MEAN DAILY SOLAR RADIATION (Langleys), JANUARY
SCALE OF SHADES
0 – 100
100 – 150
150 – 200
200 – 250
250 – 300
300 – 350
100
150
200
250
300
Seattle
Spokane
Portland
Pendleton
Missoula
Great Falls
Havre
Roseburg
Burns
Boise
Billings
Williston
Bismarck
Fargo
International Falls
Duluth
LAKE SUPERIOR
S. Ste. Marie
Minneapolis
Green Bay
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Caribou
Burlington
Portland
Concord
Albany
Boston
Hartford
Buffalo
Lansing
Detroit
Eureka
Pocatello
Lander
Rapid City
Huron
Winnemucca
Reno
Salt Lake City
Cheyenne
North Platte
Lincoln
Dubuque
Des Moines
Chicago
Sacramento
San Francisco
Fresno
Tonopah
Milford
Grand Junction
Denver
Kansas City
Springfield
Indianapolis
Columbus
Pittsburgh
Harrisburg
New York
Philadelphia
Washington
Charleston
Lexington
St. Louis
Richmond
Norfolk
Las Vegas
Dodge City
Nashville
Knoxville
Raleigh
Hatteras
Los Angeles
San Diego
Albuquerque
Amarillo
Oklahoma City
Memphis
Little Rock
Columbia
Wilmington
Phoenix
Yuma
Birmingham
Atlanta
Charleston
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
ALASKA
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome
16
Fairbanks
36
Bethel
33
Matanuska
Seward
Yakutat
Juneau
Sitka
52
Annette
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Honolulu
363
Mauna Loa
516
San Juan
404
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

MEAN DAILY SOLAR RADIATION (Langleys), JANUARY

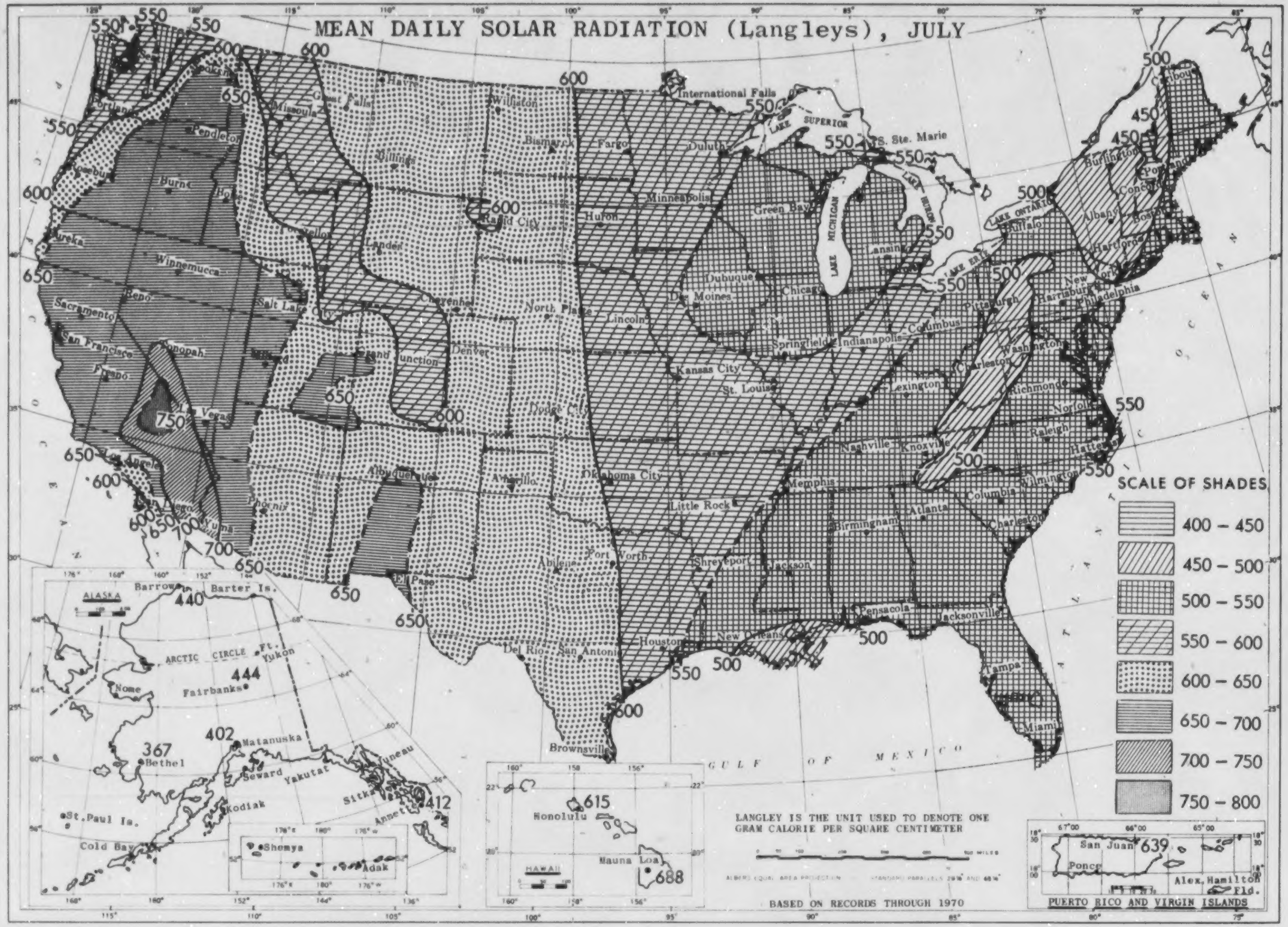
* AT BARROW SUN REMAINS BELOW HORIZON NOV. 19 THROUGH JAN. 23, INCLUSIVE

LANGLEY IS THE UNIT USED TO DENOTE ONE GRAM CALORIE PER SQUARE CENTIMETER

BASED ON RECORDS THROUGH 1970

Map 54

MEAN DAILY SOLAR RADIATION (Langleys), JULY



SCALE OF SHADES
400 – 450
450 – 500
500 – 550
550 – 600
600 – 650
650 – 700
700 – 750
750 – 800
ALASKA
Barrow 440
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Fairbanks 444
Nome
Bethel 367
Matanuska 402
Seward
Yakutat
Kodiak
Juneau
Sitka
Annette 412
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Honolulu 615
Mauna Loa 688
PUERTO RICO AND VIRGIN ISLANDS
San Juan 639
Ponce
Alex. Hamilton Fld.
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE

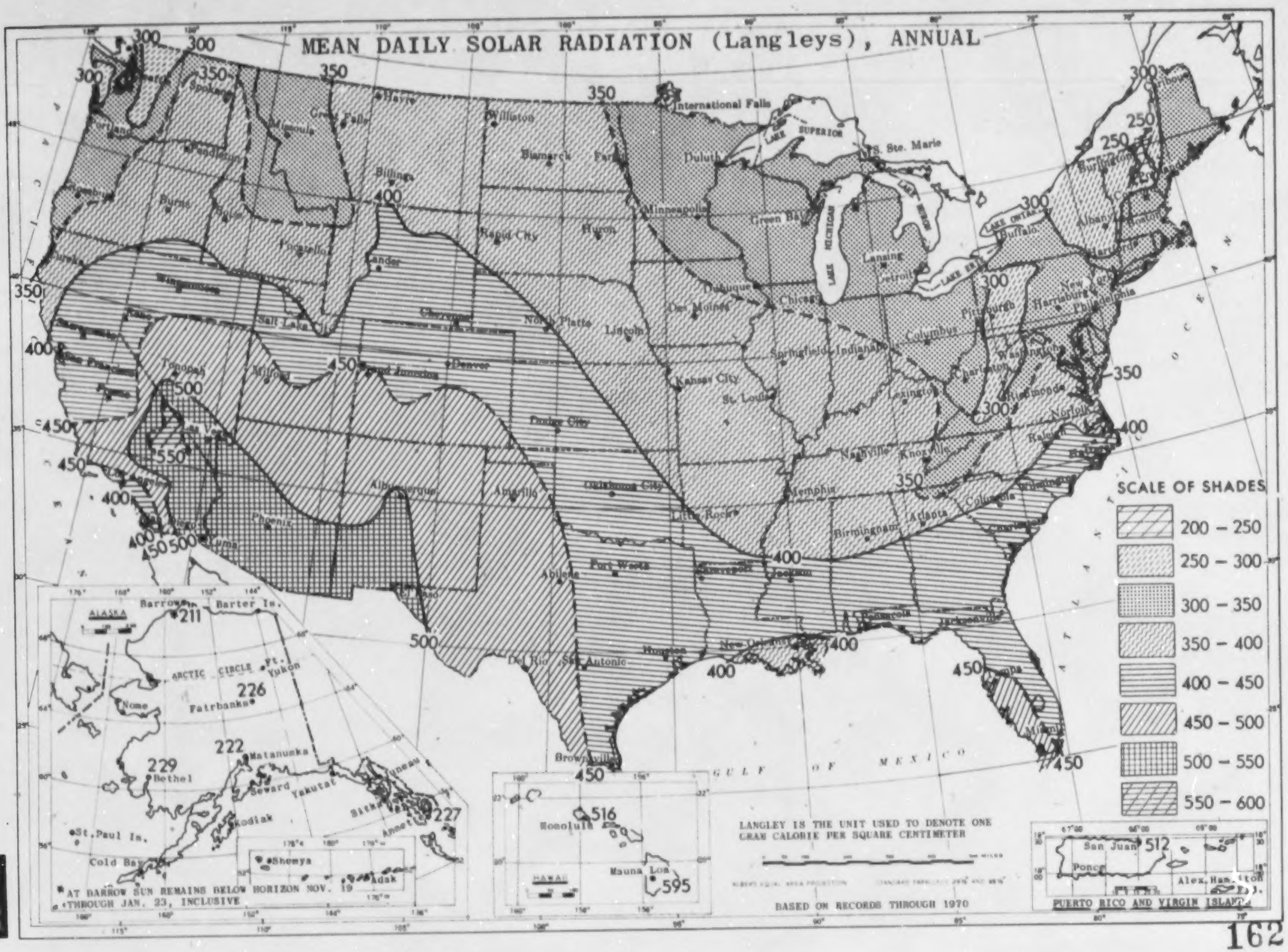
LANGLEY IS THE UNIT USED TO DENOTE ONE GRAM CALORIE PER SQUARE CENTIMETER

ALBERS EQUAL AREA PROJECTION

BASED ON RECORDS THROUGH 1970

Map 55

MEAN DAILY SOLAR RADIATION (Langleys), ANNUAL


SCALE OF SHADES
▨ 200 – 250
▨ 250 – 300
▨ 300 – 350
▨ 350 – 400
▤ 400 – 450
▨ 450 – 500
▦ 500 – 550
▨ 550 – 600
300
350
400
450
500
550
International Falls
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
S. Ste. Marie
Havre
Great Falls
Spokane
Missoula
Portland
Pendleton
Billings
Williston
Bismarck
Fargo
Duluth
Minneapolis
Green Bay
Lansing
Detroit
Buffalo
Albany
Burlington
Caribou
Boise
Burns
Pocatello
Lander
Rapid City
Huron
Winnemucca
Salt Lake
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Pittsburgh
Harrisburg
New York
Philadelphia
Columbus
Indianapolis
Springfield
Tonopah
Milford
Grand Junction
Denver
Kansas City
St. Louis
Lexington
Charleston
Washington
Richmond
Norfolk
Raleigh
Las Vegas
Dodge City
Nashville
Knoxville
Albuquerque
Amarillo
Oklahoma City
Little Rock
Memphis
Atlanta
Columbia
Charleston
Phoenix
Yuma
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Birmingham
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALASKA
Barrow 211
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
226
Nome
Fairbanks
229
Bethel
222
Matanuska
Seward
Yakutat
Kodiak
Sitka
Juneau
Annette
227
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
516
Honolulu
Mauna Loa
595
San Juan 512
Ponce
Alex. Hamilton
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

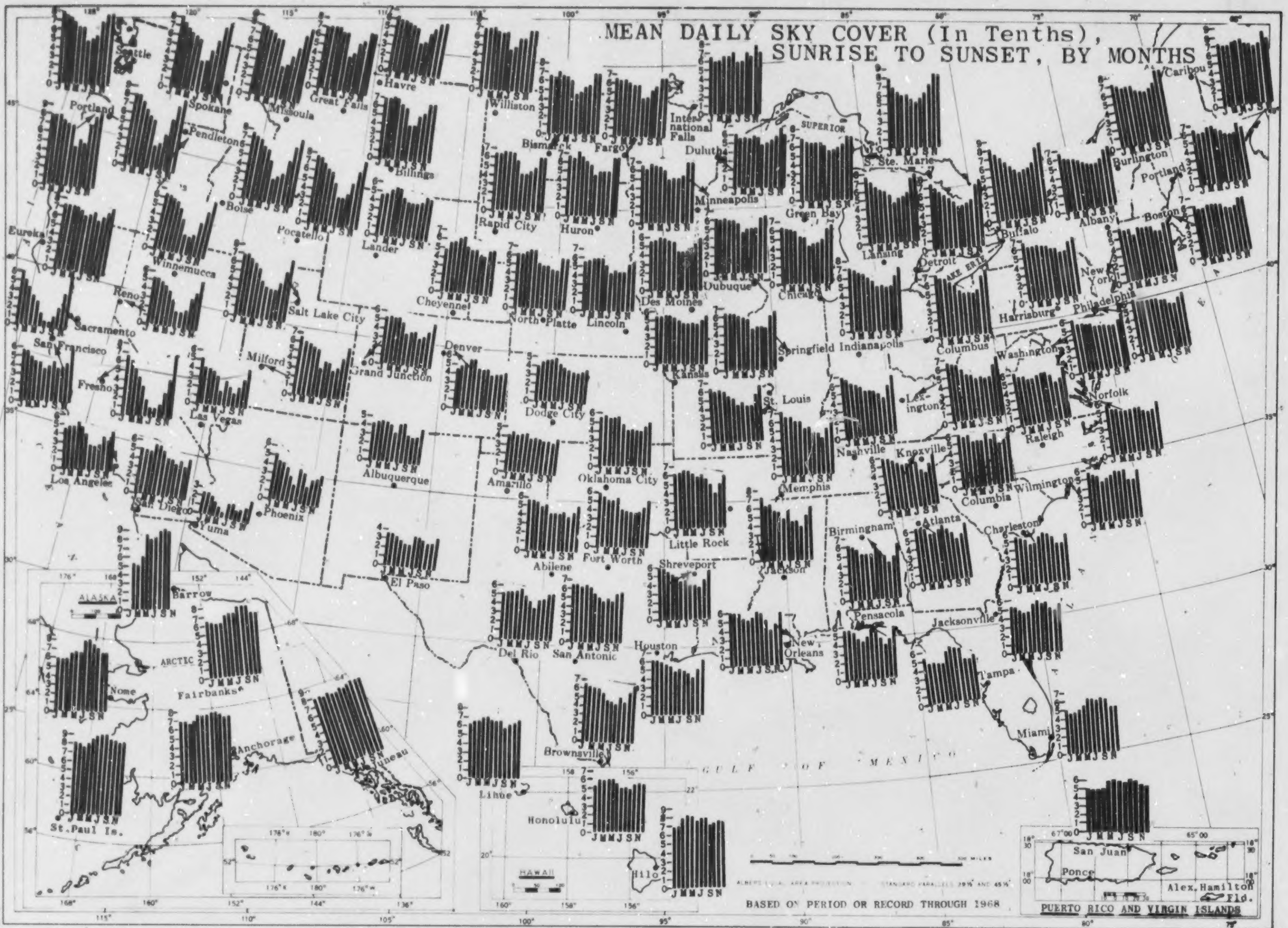
AT BARROW SUN REMAINS BELOW HORIZON NOV. 19 THROUGH JAN. 23, INCLUSIVE

LANGLEY IS THE UNIT USED TO DENOTE ONE GRAM CALORIE PER SQUARE CENTIMETER

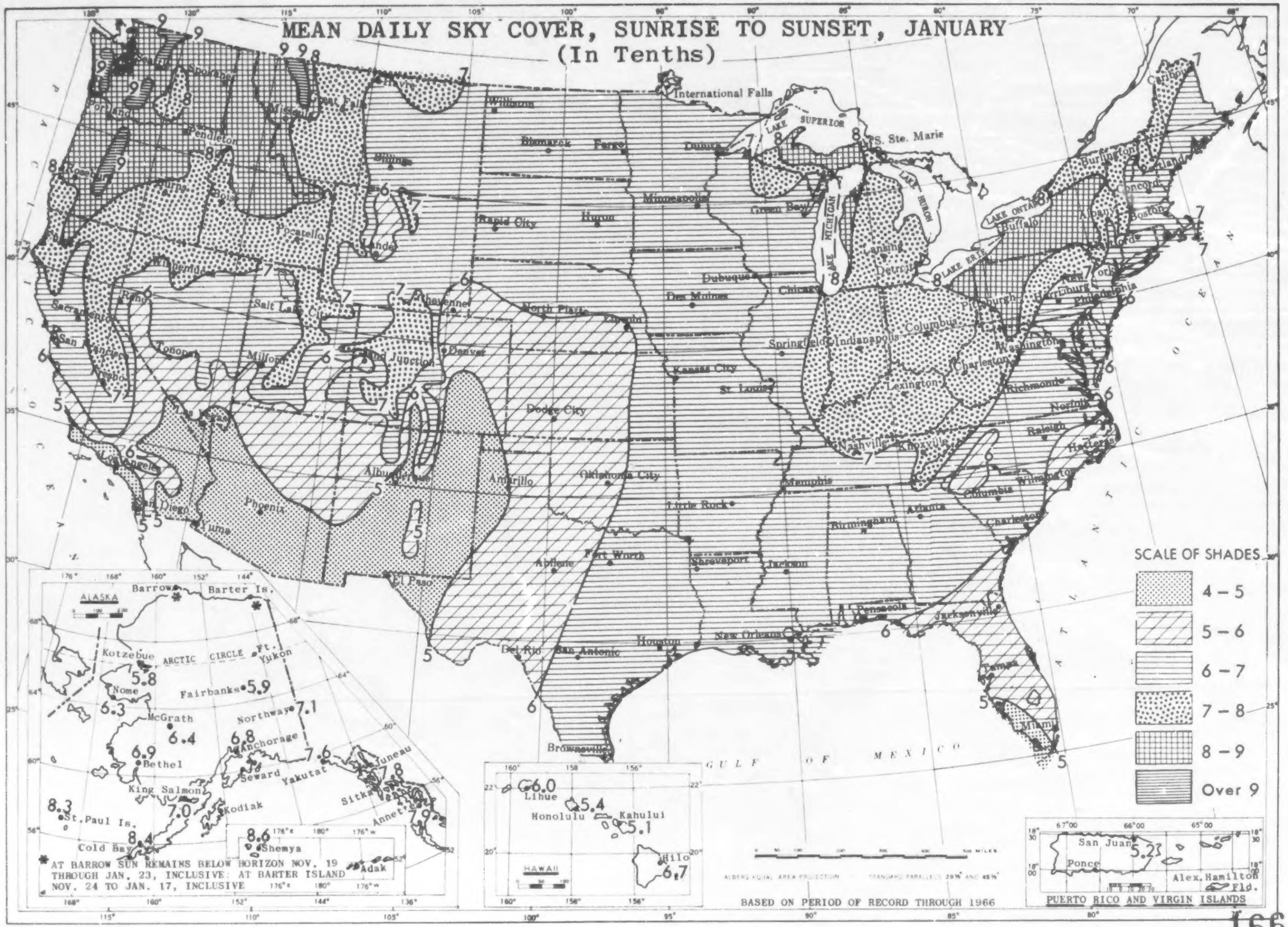
BASED ON RECORDS THROUGH 1970

Map 56

MEAN DAILY SKY COVER (In Tenths), SUNRISE TO SUNSET, BY MONTHS


Seattle
Spokane
Missoula
Great Falls
Havre
Williston
Portland
Pendleton
Billings
Bismarck
Fargo
International Falls
Duluth
SUPERIOR
Ste. Marie
Caribou
Burlington
Portland
Boise
Pocatello
Lander
Rapid City
Huron
Minneapolis
Green Bay
Albany
Boston
Eureka
Winnemucca
Reno
Sacramento
San Francisco
Salt Lake City
Cheyenne
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
LAKE ERIE
Buffalo
New York
Harrisburg
Philadelphia
Fresno
Milford
Grand Junction
Denver
Kansas
Springfield
Indianapolis
Columbus
Washington
Norfolk
Las Vegas
Dodge City
St. Louis
Lexington
Raleigh
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Nashville
Knoxville
Memphis
Columbia
Wilmington
San Diego
Yuma
Phoenix
El Paso
Abilene
Fort Worth
Little Rock
Shreveport
Jackson
Birmingham
Atlanta
Charleston
Del Rio
San Antonio
Houston
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Brownsville
GULF OF MEXICO
ALASKA
Barrow
ARCTIC
Fairbanks
Nome
Anchorage
Juneau
St. Paul Is.
Lihue
Honolulu
Hilo
HAWAII
San Juan
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
J M M J S N
ALBERS EQUAL AREA PROJECTION STANDARD PARALLELS 29½° AND 45½°

BASED ON PERIOD OR RECORD THROUGH 1968



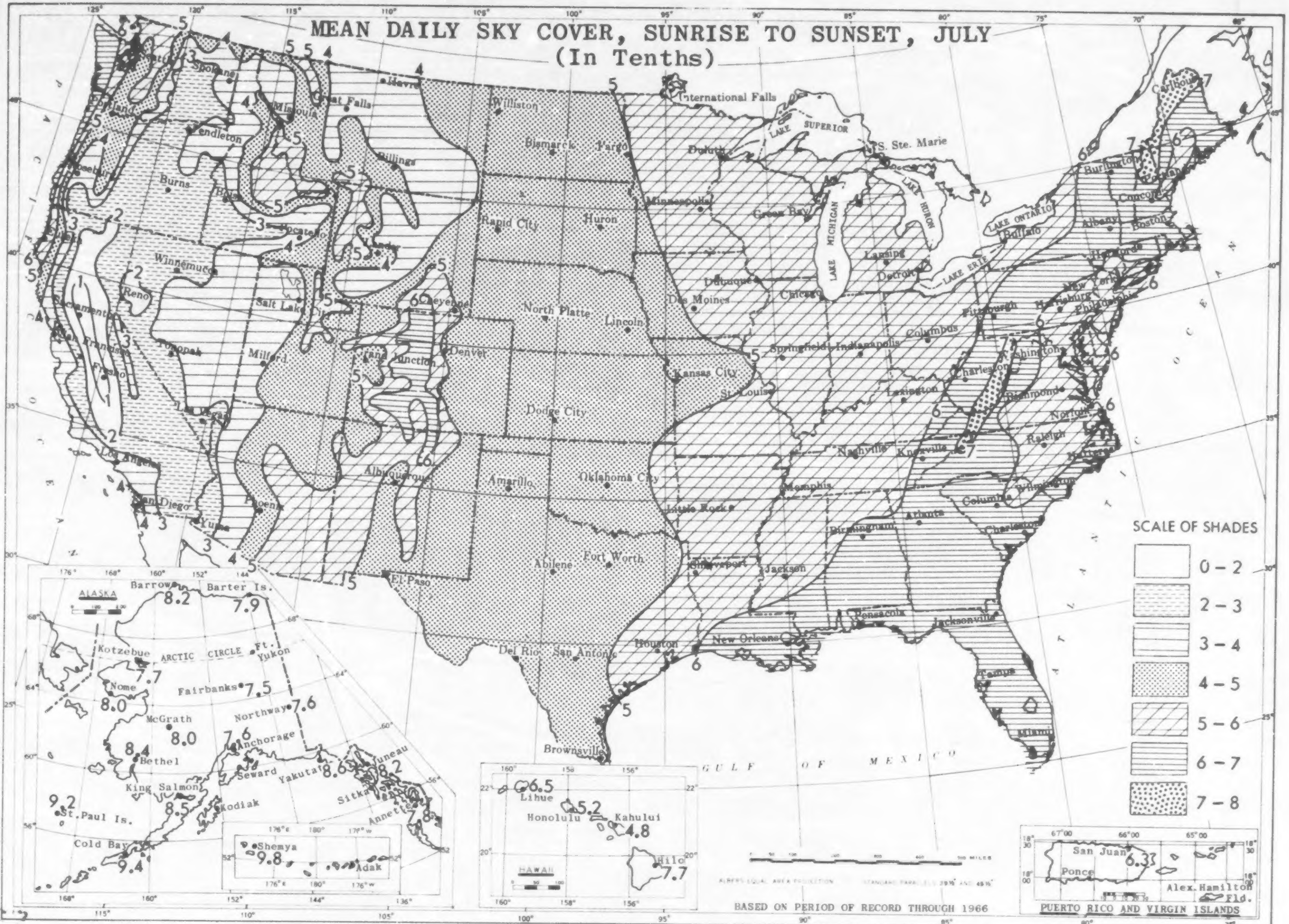
MEAN DAILY SKY COVER, SUNRISE TO SUNSET, JANUARY
(In Tenths)

* AT BARROW SUN REMAINS BELOW HORIZON NOV. 19 THROUGH JAN. 23, INCLUSIVE; AT BARTER ISLAND NOV. 24 TO JAN. 17, INCLUSIVE

BASED ON PERIOD OF RECORD THROUGH 1966

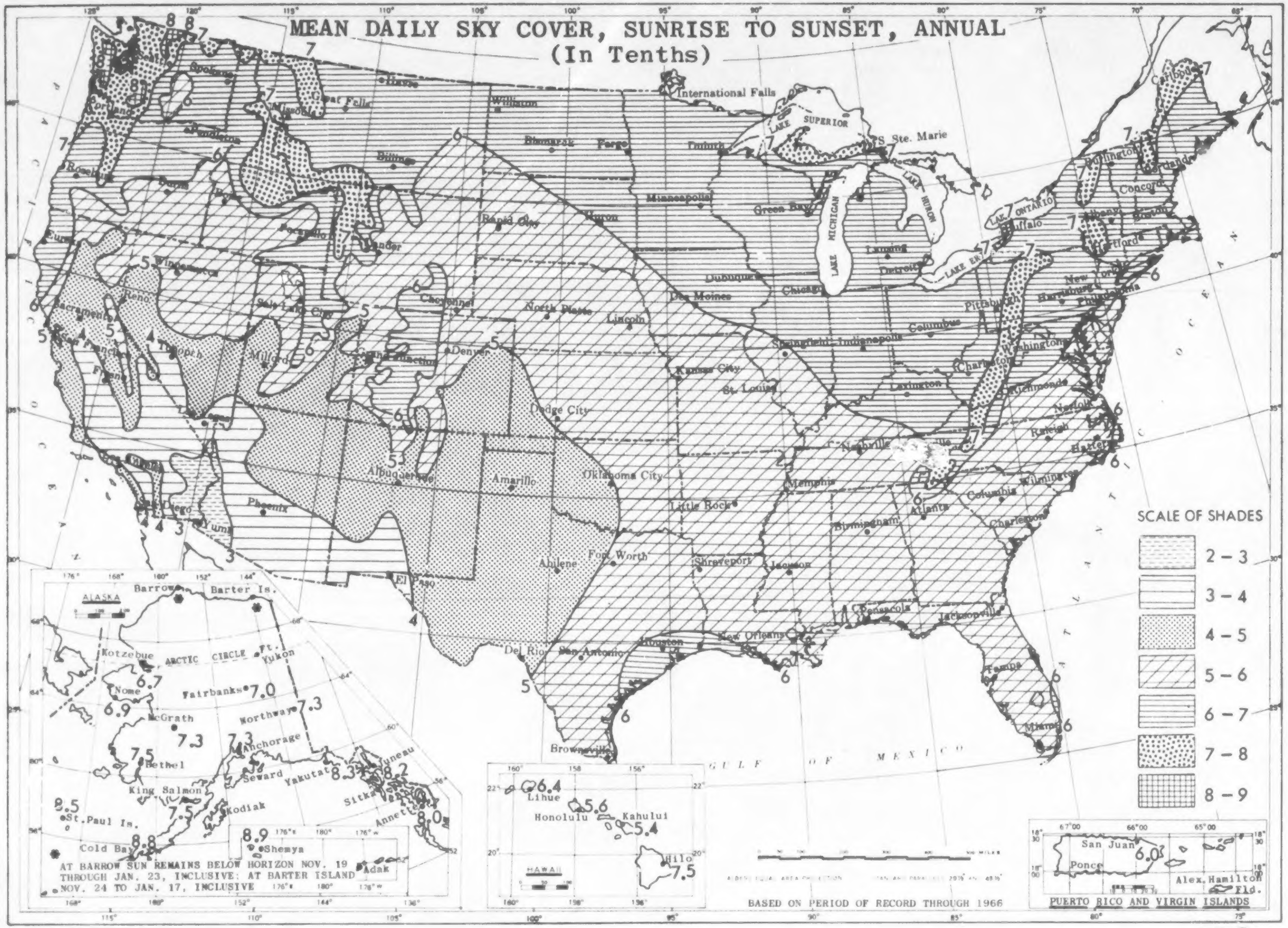
SCALE OF SHADES
4 – 5
5 – 6
6 – 7
7 – 8
8 – 9
Over 9
International Falls
Ste. Marie
Williston
Bismarck
Fargo
Duluth
Spokane
Great Falls
Pendleton
Billings
Roseburg
Boise
Pocatello
Lander
Rapid City
Huron
Minneapolis
Green Bay
Burlington
Concord
Albany
Boston
Buffalo
Lansing
Detroit
Winnemucca
Reno
Salt Lake City
Cheyenne
North Platte
Lincoln
Dubuque
Des Moines
Chicago
Pittsburgh
Harrisburg
New York
Philadelphia
Sacramento
San Francisco
Tonopah
Milford
Grand Junction
Denver
Springfield
Indianapolis
Columbus
Washington
Fresno
Kansas City
St. Louis
Charleston
Lexington
Richmond
Norfolk
Las Vegas
Dodge City
Nashville
Knoxville
Raleigh
Hatteras
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Little Rock
Columbia
Wilmington
San Diego
Phoenix
Yuma
Birmingham
Atlanta
Charleston
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
Del Rio
San Antonio
Houston
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
ALASKA
Barrow
Barter Is.
Kotzebue
ARCTIC CIRCLE
Ft. Yukon
5.8
Nome
Fairbanks 5.9
6.3
McGrath
Northway 7.1
6.4
6.8
Anchorage
6.9
Bethel
7.6
Juneau
King Salmon
Seward
Yakutat
8.3
St. Paul Is.
7.0
Kodiak
Sitka
Annette
7.9
8.4
Cold Bay
8.6
Shemya
Adak
6.0
Lihue
5.4
Honolulu
Kahului
5.1
Hilo
6.7
HAWAII
San Juan
5.2
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

Map 58



MEAN DAILY SKY COVER, SUNRISE TO SUNSET, JULY
(In Tenths)

SCALE OF SHADES
0 – 2
2 – 3
3 – 4
4 – 5
5 – 6
6 – 7
7 – 8
ALASKA
Barrow 8.2
Barter Is. 7.9
Kotzebue 7.7
ARCTIC CIRCLE
Ft. Yukon
Nome 8.0
Fairbanks 7.5
Northway 7.6
McGrath 8.0
Anchorage 7.6
Bethel 8.4
King Salmon 8.5
Seward
Yakutat 8.6
Juneau 8.2
Sitka
Annette 7.8
Kodiak
St. Paul Is. 9.2
Cold Bay 9.4
Shemya 9.8
Adak
HAWAII
Lihue 6.5
Honolulu 5.2
Kahului 4.8
Hilo 7.7
PUERTO RICO AND VIRGIN ISLANDS
San Juan 6.3
Ponce
Alex. Hamilton Fld.
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALBERS EQUAL AREA PROJECTION
BASED ON PERIOD OF RECORD THROUGH 1966



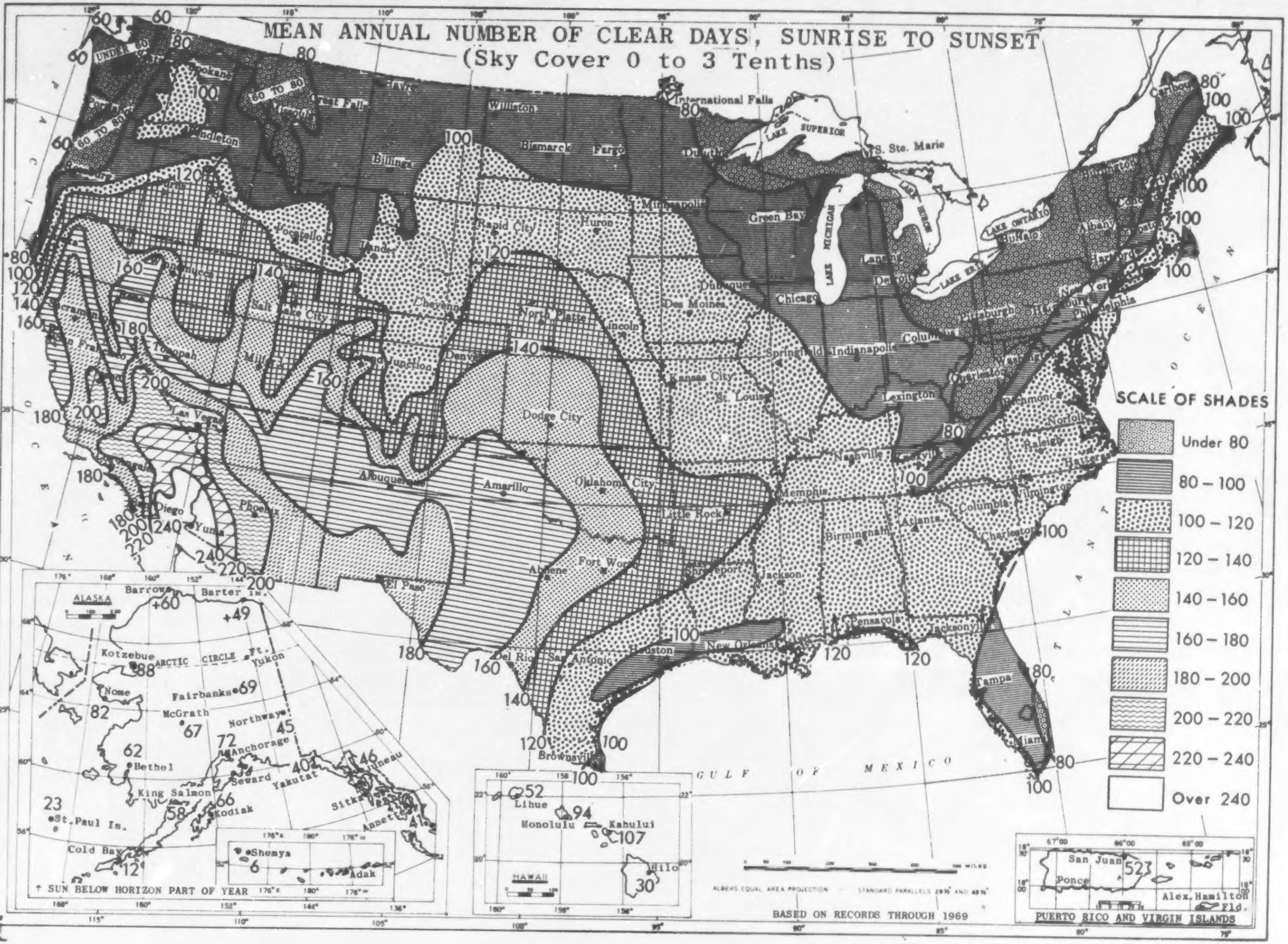
MEAN DAILY SKY COVER, SUNRISE TO SUNSET, ANNUAL
(In Tenths)

AT BARROW SUN REMAINS BELOW HORIZON NOV. 19 THROUGH JAN. 23, INCLUSIVE; AT BARTER ISLAND NOV. 24 TO JAN. 17, INCLUSIVE

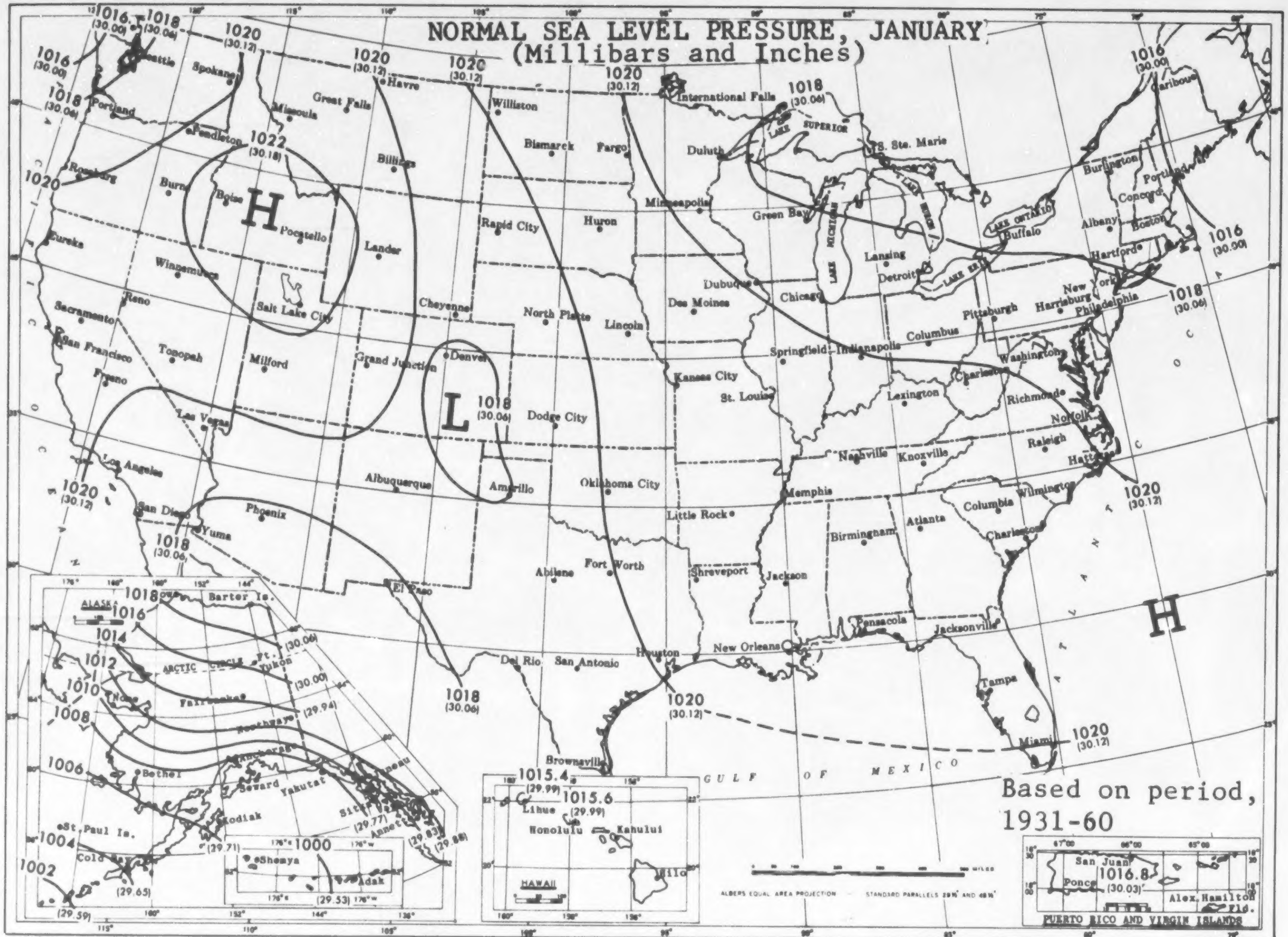
BASED ON PERIOD OF RECORD THROUGH 1966

SCALE OF SHADES
2 – 3
3 – 4
4 – 5
5 – 6
6 – 7
7 – 8
8 – 9
International Falls
LAKE SUPERIOR
S. Ste. Marie
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Caribou
Burlington
Portland
Concord
Albany
Boston
Hartford
Buffalo
New York
Harrisburg
Philadelphia
Pittsburgh
Washington
Charleston
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Atlanta
Jacksonville
Tampa
Miami
Havre
Great Falls
Missoula
Spokane
Pendleton
Portland
Roseburg
Eureka
Williston
Bismarck
Fargo
Duluth
Minneapolis
Green Bay
Lansing
Detroit
Chicago
Dubuque
Des Moines
Huron
Rapid City
Billings
Boise
Pocatello
Lander
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Milford
Salt Lake City
Cheyenne
Grand Junction
Denver
North Platte
Lincoln
Kansas City
St. Louis
Springfield
Indianapolis
Columbus
Lexington
Nashville
Memphis
Little Rock
Birmingham
Jackson
Shreveport
New Orleans
Pensacola
Houston
San Antonio
Del Rio
Brownsville
Abilene
Fort Worth
Oklahoma City
Amarillo
Dodge City
Albuquerque
El Paso
Phoenix
Yuma
San Diego
Los Angeles
GULF OF MEXICO
ALASKA
Barrow
Barter Is.
Kotzebue
ARCTIC CIRCLE
Ft. Yukon
Nome 6.7
Fairbanks 7.0
6.9
McGrath
7.3
Northway 7.3
Anchorage 7.3
7.5 Bethel
Seward
Yakutat 8.3
Juneau 8.2
Sitka
Annette 8.0
King Salmon
7.5 Kodiak
8.5 St. Paul Is.
8.8 Cold Bay
8.9 Shemya
Adak
HAWAII
6.4 Lihue
Honolulu 5.6
Kahului 5.4
Hilo 7.5
San Juan 6.0
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS

Map 60


MEAN ANNUAL NUMBER OF CLEAR DAYS, SUNRISE TO SUNSET
(Sky Cover 0 to 3 Tenths)

SCALE OF SHADES
Under 80
80 – 100
100 – 120
120 – 140
140 – 160
160 – 180
180 – 200
200 – 220
220 – 240
Over 240
UNDER 60
60 TO 80
International Falls
LAKE SUPERIOR
S. Ste. Marie
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Williston
Bismarck
Fargo
Duluth
Minneapolis
Green Bay
Rapid City
Huron
Billings
Pendleton
Spokane
Pocatello
Lander
Cheyenne
Denver
North Platte
Lincoln
Des Moines
Dubuque
Chicago
Lansing
Detroit
Buffalo
Albany
Burlington
Caribou
Pittsburgh
Harrisburg
New York
Philadelphia
Columbus
Indianapolis
Springfield
Kansas City
St. Louis
Lexington
Charleston
Richmond
Norfolk
Raleigh
Hatteras
Nashville
Knoxville
Memphis
Little Rock
Oklahoma City
Dodge City
Amarillo
Albuquerque
Grand Junction
Salt Lake City
Milford
Tonopah
Las Vegas
Sacramento
San Francisco
Los Angeles
San Diego
Yuma
Phoenix
El Paso
Abilene
Fort Worth
Shreveport
Jackson
Birmingham
Atlanta
Columbia
Wilmington
Charleston
Pensacola
Jacksonville
New Orleans
Houston
San Antonio
Del Rio
Brownsville
Tampa
Miami
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
60
80
100
120
140
160
180
200
220
240
ALASKA
Barrow +60
Barter Is. +49
Kotzebue 88
ARCTIC CIRCLE
Ft. Yukon
Nome 82
Fairbanks 69
McGrath 67
Northway 45
Anchorage 72
Bethel 62
Seward
Yakutat 40
Juneau 46
King Salmon 58
Kodiak 66
Sitka
Annette 41
St. Paul Is. 23
Cold Bay 12
Shemya 6
Adak
+ SUN BELOW HORIZON PART OF YEAR
HAWAII
Lihue 52
Honolulu 94
Kahului 107
Hilo 30
San Juan 52
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°
BASED ON RECORDS THROUGH 1969



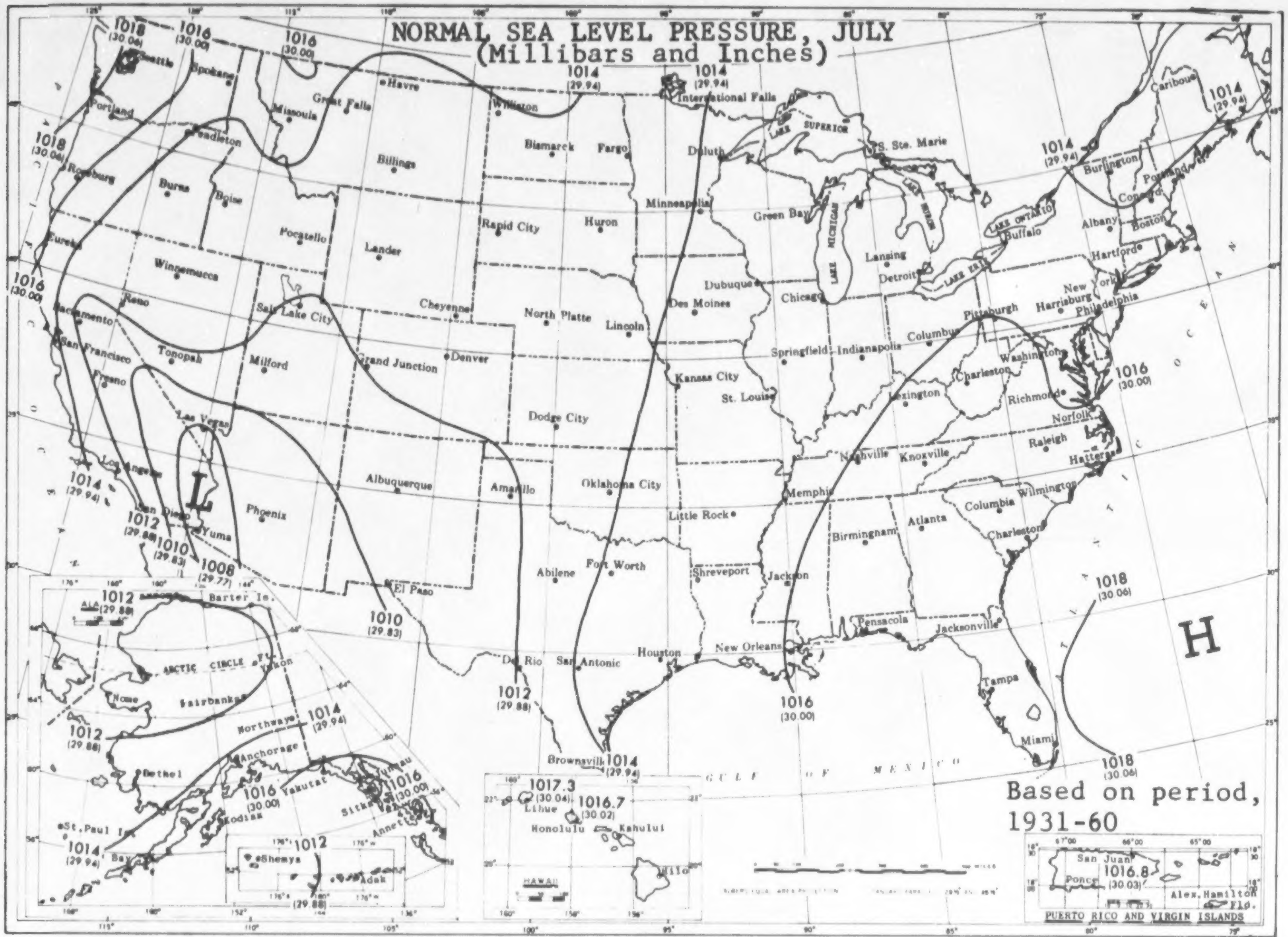
NORMAL SEA LEVEL PRESSURE, JANUARY
(Millibars and Inches)

1016 (30.00)
1018 (30.06)
1020 (30.12)
1022 (30.18)
H
L
1018 (30.06)
1020 (30.12)
Seattle
Spokane
Portland
Pendleton
Roseburg
Eureka
Burns
Boise
Pocatello
Missoula
Great Falls
Havre
Billings
Lander
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Salt Lake City
Milford
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
El Paso
Albuquerque
Grand Junction
Denver
Cheyenne
Amarillo
Dodge City
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Des Moines
Kansas City
St. Louis
Springfield
Dubuque
Chicago
Green Bay
Lansing
Detroit
Indianapolis
Columbus
Pittsburgh
Lexington
Nashville
Knoxville
Memphis
Little Rock
Shreveport
Jackson
Birmingham
Atlanta
New Orleans
Pensacola
Jacksonville
Tampa
Miami
Charleston
Columbia
Wilmington
Raleigh
Hatteras
Norfolk
Richmond
Washington
Charleston
Philadelphia
Harrisburg
New York
Hartford
Boston
Albany
Concord
Portland
Burlington
Caribou
Buffalo
S. Ste. Marie
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
ALASKA
1018
1016
1014
1012
1010
1008
1006
1004
1002
1000
(30.06)
(30.00)
(29.94)
(29.77)
(29.83)
(29.88)
(29.71)
(29.65)
(29.59)
(29.53)
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Fairbanks
Nome
Northway
Anchorage
Bethel
Seward
Yakutat
Kodiak
Sitka
Annette
Juneau
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
1015.4 (29.99)
1015.6 (29.99)
Lihue
Honolulu
Kahului
Hilo
San Juan
Ponce
1016.8 (30.03)
Alex.Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29½° AND 45½°

Based on period, 1931-60

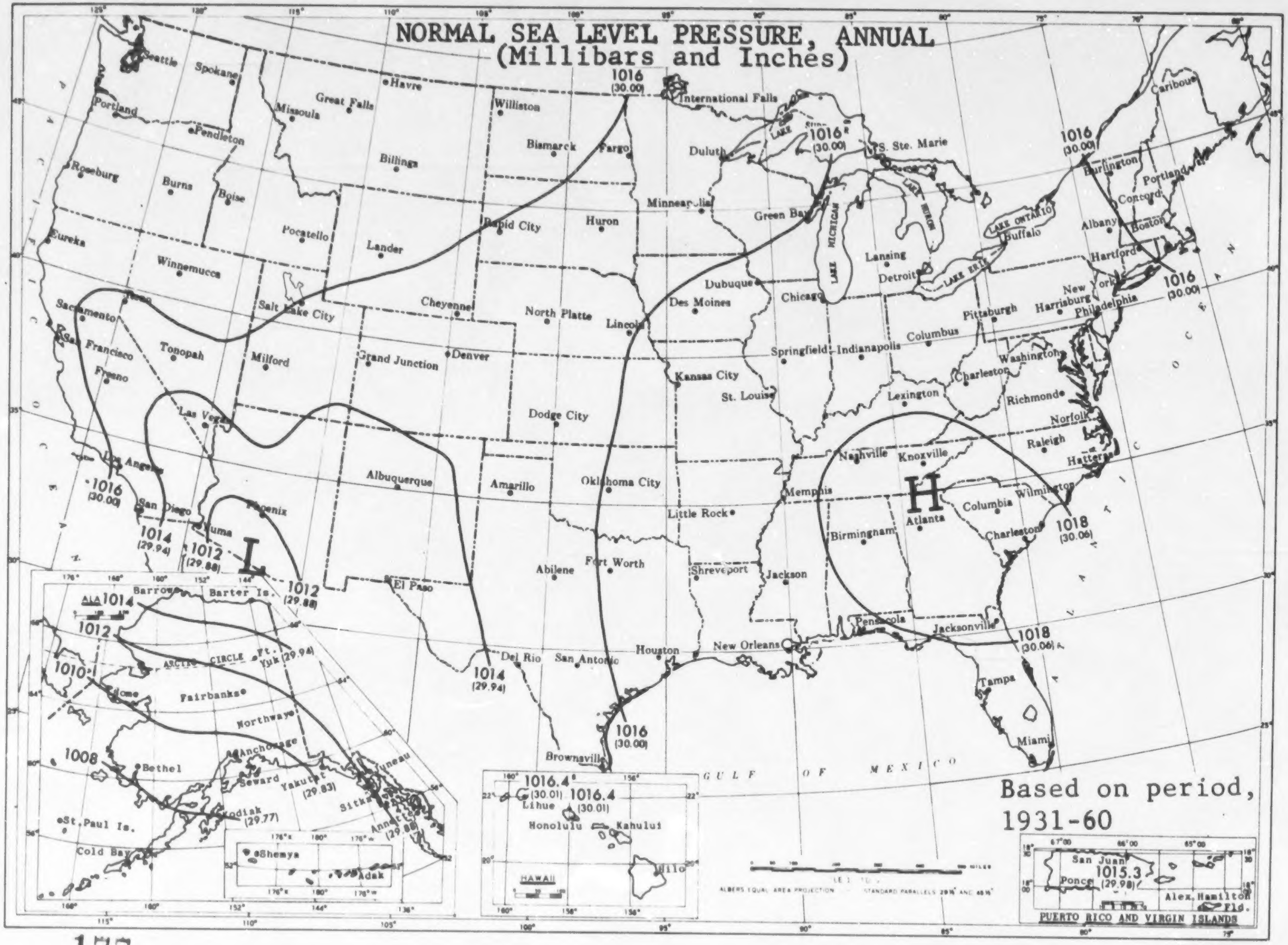
Map 62

NORMAL SEA LEVEL PRESSURE, JULY
(Millibars and Inches)


1018 (30.06)
1016 (30.00)
1014 (29.94)
1012 (29.88)
1010 (29.83)
1008 (29.77)
L
H
1016.7 (30.02)
1017.3 (30.04)
1016.8 (30.03)
Seattle
Spokane
Portland
Roseburg
Eureka
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Yuma
Las Vegas
Phoenix
Reno
Winnemucca
Tonopah
Milford
Salt Lake City
Pocatello
Boise
Burns
Pendleton
Missoula
Great Falls
Havre
Billings
Lander
Cheyenne
Denver
Grand Junction
Albuquerque
El Paso
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Des Moines
Dubuque
Kansas City
St. Louis
Little Rock
Shreveport
Jackson
New Orleans
Memphis
Nashville
Knoxville
Birmingham
Atlanta
Pensacola
Jacksonville
Tampa
Miami
Chicago
Springfield
Indianapolis
Green Bay
Lansing
Detroit
S. Ste. Marie
Columbus
Lexington
Charleston
Pittsburgh
Harrisburg
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Buffalo
Albany
Hartford
New York
Philadelphia
Burlington
Concord
Boston
Portland
Caribou
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
ALASKA
Barter Is.
ARCTIC CIRCLE
Ft. Yukon
Nome
Fairbanks
Northway
Anchorage
Bethel
Yakutat
Juneau
Sitka
Annette
Kodiak
St. Paul Is.
Cold Bay
Shemya
Adak
HAWAII
Lihue
Honolulu
Kahului
Hilo
PUERTO RICO AND VIRGIN ISLANDS
San Juan
Ponce
Alex. Hamilton Fld.

Based on period, 1931-60

Map 63



NORMAL SEA LEVEL PRESSURE, ANNUAL
(Millibars and Inches)

Based on period, 1931-60

1016 (30.00)
1014 (29.94)
1012 (29.88)
1018 (30.06)
L
H
Seattle
Spokane
Portland
Pendleton
Roseburg
Burns
Boise
Eureka
Winnemucca
Reno
Sacramento
San Francisco
Fresno
Tonopah
Las Vegas
Los Angeles
San Diego
Yuma
Phoenix
Missoula
Great Falls
Havre
Billings
Pocatello
Lander
Salt Lake City
Milford
Grand Junction
Denver
Cheyenne
Albuquerque
El Paso
Williston
Bismarck
Fargo
Rapid City
Huron
North Platte
Lincoln
Dodge City
Amarillo
Oklahoma City
Abilene
Fort Worth
Del Rio
San Antonio
Houston
Brownsville
International Falls
Duluth
Minneapolis
Green Bay
Des Moines
Dubuque
Chicago
Kansas City
St. Louis
Springfield
Indianapolis
Little Rock
Shreveport
Memphis
Jackson
New Orleans
Nashville
Knoxville
Birmingham
Atlanta
Pensacola
Jacksonville
Tampa
Miami
S. Ste. Marie
Lansing
Detroit
Columbus
Lexington
Charleston
Pittsburgh
Buffalo
Harrisburg
Philadelphia
New York
Washington
Richmond
Norfolk
Raleigh
Hatteras
Wilmington
Columbia
Charleston
Albany
Hartford
Boston
Concord
Portland
Burlington
Caribou
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
ALA 1014
1012
1010
1008
Barrow
Barter Is.
ARCTIC CIRCLE
Ft. Yuk (29.94)
Nome
Fairbanks
Northway
Bethel
Anchorage
Seward
Yakutat (29.83)
Kodiak (29.77)
Juneau
Sitka
Annette (29.88)
St. Paul Is.
Cold Bay
Shemya
Adak
1016.4 (30.01)
Lihue
Honolulu
Kahului
Hilo
HAWAII
San Juan
1015.3 (29.98)
Ponce
Alex. Hamilton Fld.
PUERTO RICO AND VIRGIN ISLANDS
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°

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